Technical and Bibliographic Notes / Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming are checked below.

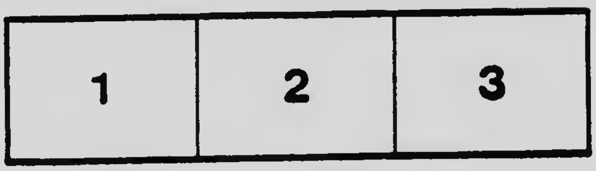
- [x] Coloured covers / Couverture de couleur
- [ ] Covers damaged / Couverture endommagée
- [ ] Covers restored and/or laminated / Couverture restaurée et/ou pelliculée
- [ ] Cover title missing / Le titre de couverture manque
- [ ] Coloured maps / Cartes géographiques en couleur
- [ ] Coloured ink (i.e. other than blue or black) / Encre de couleur (i.e. autre que bleue ou noire)
- [x] Coloured plates and/or illustrations / Planches et/ou illustrations en couleur
- [ ] Bound with other material / Relié avec d'autres documents
- [ ] Only edition available / Seule édition disponible
- [ ] Tight binding may cause shadows or distortion along interior margin / La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure.
- [ ] Blank leaves added during restorations may appear within the text. Whenever possible, these have been omitted from filming / Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.
- [ ] Additional comments / Commentaires supplémentaires:

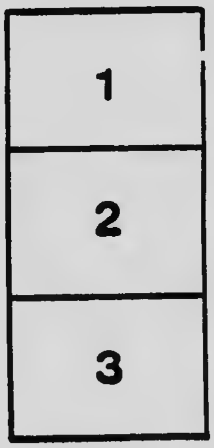
L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

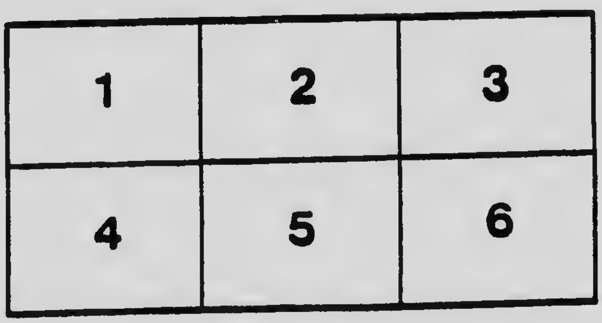
- [ ] Coloured pages / Pages de couleur
- [ ] Pages damaged / Pages endommagées
- [ ] Pages restored and/or laminated / Pages restaurées et/ou pelliculées
- [x] Pages discoloured, stained or foxed / Pages décolorées, tachetées ou piquées
- [ ] Pages detached / Pages détachées
- [x] Showthrough / Transparence
- [ ] Quality of print varies / Qualité inégale de l'impression
- [ ] Includes supplementary material / Comprend du matériel supplémentaire
- [ ] Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image / Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.
- [ ] Opposing pages with varying colouration or discolourations are filmed twice to ensure the best possible image / Les pages s'opposant ayant des colorations variables ou des décolorations sont filmées deux fois afin d'obtenir la meilleure image possible.

This item is filmed at the reduction ratio checked below /
Ce document est filmé au taux de réduction indiqué ci-dessous.

10x 12x 14x 16x 18x 20x 22x 24x ✓ 26x 28x 30x 32x

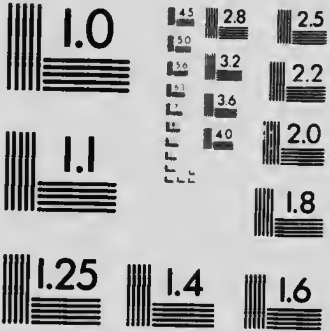

1
2
3


1
2
3


1
2
3
4
5
6

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



APPLIED IMAGE Inc
1653 East Main Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phone
(716) 288 - 5989 - Fax

Water Powers of Canada

Province of

British Columbia

By G. R. G. Conway

"An examination of any good map of our broad Dominion, reveals, as its most striking feature, an extraordinary wealthy and remarkably uninterrupted succession of lakes and rivers, suggestive of ample rainfall, the first great requisite in the occupation of any country. Over a length of several thousand miles, between Labrador and Alaska, and over a width of several hundred miles, there is an almost continuous distribution of lakes; lakelets and rivers; the lakes of varied outlines, dimensions and elevations above sea level, and many possessing facilities for the storage of their flood waters. In many places the outlet from the lake or the connection between a chain of lakes is a narrow cleft in rock where an inexpensive dam will hold back the water supplied by the winter's accumulation of snow."

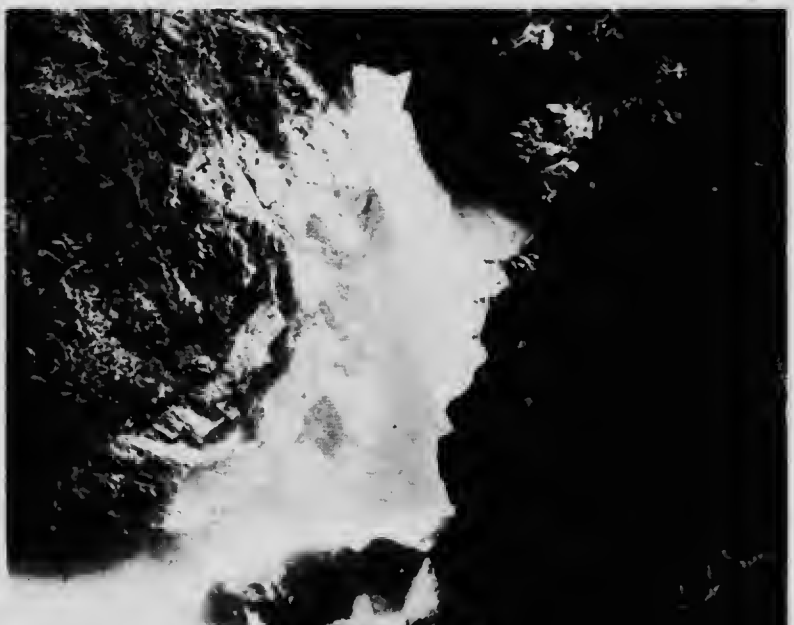
From a Presidential address on the Water Powers of Canada before the Royal Society of Canada, in 1898-99, by the late T. C. Keefer, C.E., C.M.G., Honorary Member of the Institute, American Society and Canadian Society, of Civil Engineers; Past President of the American and Canadian Societies of Civil Engineers.

Water Powers of Canada

Province of

British Columbia

By G. R. G. Conway



Dominion Water Power Branch

Department of the Interior

Ottawa, Canada

CONTENTS

THIS little book on the Water Powers of the Province of British Columbia, published by direction of the Honourable W. J. Roche, Minister of the Interior, Canada, was written by G. R. G. Conway, M.Inst.C.E., M.Can.Soc.C.E., M.Am.Soc.C.E., Consulting Engineer to the British Columbia Electric Railway, at the request of the Superintendent of the Dominion Water Power Branch, for distribution in connection with the water power exhibit of the Dominion Government in the Canadian Pavilion at the Panama-Pacific Exposition.

This water power exhibit was prepared by the Dominion Water Power Branch under the direction of the Commissioner General of Canadian exhibitions, with the object of showing visitors to the Exposition the tremendous water power resources of Canada and especially the great progress already made in the art of power development and use throughout the Dominion.

The outstanding feature of the water power situation in Canada, is the fact that practically all industrial and commercial centres in the Dominion from coast to coast have sufficient potential water power within easy transmission radius and of sufficient capacity and assured economic feasibility of development to meet all anticipated requirements for the future.

INTRODUCTION

THIS booklet professes to be merely an outline sketch of a great subject but its purpose is to draw attention to the opportunities that obtain in British Columbia for utilising the great natural sources of energy, and to stimulate interest in making the vast water powers of the Province valuable to the community.

In its preparation the writer has received valuable assistance from many quarters, and he wishes to acknowledge the information so willingly placed at his disposal by the engineers and representatives of the various power companies, and amongst others from Mr. Lorne Campbell, M.P.P., C.E., General Manager, West Kootenay Power & Light Company, Limited; Mr. George Kidd, General Manager, British Columbia Electric Railway Company, Limited; Mr. R. F. Hayward, M.Can.Soc.C.E., General Manager and Chief Engineer, Western Canada Power Company, Limited; Mr. Joseph Hunter, M.Can.Soc.C.E., Chief Engineer, Canadian Collieries (Dunsmuir), Limited; Mr. F. W. Sylvester, General Manager, Granby Consolidated Mining, Smelting & Power Company, Limited; Messrs. Ducane, Dutcher & Company, Consulting Engineers for City of Kamloops; Mr. A. R. Mackenzie, Assoc.M.Inst.C.E., Consulting Engineer, Couteau Power Company; Mr. G. P. Jones, Superintendent, Hedley Gold Mining Company; Mr. J. W. D. Moodie, General Manager, Britannia Mining & Smelting Company, Limited; and Mr. A. B. Martin, Receiver for Ocean Falls Company, Limited.

The writer also wishes to express his thanks for the assistance he has received from Mr. J. B. Challies, M.Can.Soc.C.E., Superintendent of the Dominion Water Power Branch, Ottawa; Mr. James White, M.Can.Soc.C.E., Deputy Chairman, Dominion Commission of Conservation; Mr. William Young, M.Can.Soc.C.E., Comptroller of Water Rights, British Columbia; Mr. R. G. Swan, Chief Engineer British Columbia Hydrographic Survey; Prof. R. W. Brock, Dean of Applied Science, University of British Columbia; Mr. E. B. Shearman, Meteorological Office, Vancouver; and to Mr. F S. Easton, B.Sc., Assoc.M.Inst.C.E. (the writer's Assistant), he is also indebted for compiling much of the information contained herein.

G. R. G. C.

VANCOUVER, B.C., February, 1915.

WATER POWERS OF BRITISH COLUMBIA

PHYSICAL AND GEOLOGICAL CHARACTERISTICS OF THE PROVINCE

THE province of British Columbia has a superficial area of 372,640 square miles, and within its boundaries there are vast undeveloped resources of mineral and timber wealth. The value of these great resources of wealth is enormously increased by the long Pacific coast line with its numerous excellent harbours, with the great navigable rivers and lakes, great railway systems, and by numerous water powers that are capable of development for the transmission of electrical energy over practically the whole of the mining, industrial and populated areas of the Province.

British Columbia* may be described as a great quadrangle 700 miles in length by 400 miles in width, lying to the north of the 49th parallel, and west of the centre core of the Rocky Mountains, extending along the Pacific coast as far as latitude 55°, and including the islands adjacent. North of that degree of latitude it continues inland to latitude 60°, but is shut off from the coast by the narrow strip of Alaskan territory and is bounded on the east, north of latitude 54°, by longitude 120°. The southern half of the province lies between well defined boundaries. It forms a large and rugged rhomboid of elevated land, which is supported on each side by ranges of mountains. On the east these are the Rockies and Selkirks, and the Coast and Island ranges on the west. The easternmost range is that of the Rocky Mountains, which is the northern extremity of the great Cordilleran belt, which forms the back bone of the North American continent from Mexico to Alaska. This range enters the province at the 49th parallel, and constitutes the eastern boundary of the province to latitude 54°, continuing to between 56° and 57°, where it loses its distinctive character, merging into lower hills. Geologists have shown that this great range consists of the upturned edges of the strata that underlies the great North-West plain, and its massive mountains are formed chiefly of alluvial and carboniferous limestone. The average height of the range is roughly about 8,000 feet, but there are several summits in the vicinity of the Bow River and the Kicking Horse Pass which attain an elevation of between 10,000 and 13,500 feet. There are twelve principal passes through the mountains, at elevations ranging from 7,100 feet, the highest being the South Kootenay Pass, and the lowest the Peace River Valley Pass, which is at elevation [illegible],000 feet.

Parallel to the Rocky Mountains runs the Selkirk range. This range has been shown by geologists to represent an earlier upheaval, and to exhibit an entirely different series of rocks. Entering from the south in a three-fold system developed by important valleys, these ranges have been called respectively the Purcell, Selkirks, and the Gold Mountains. To the north of the Great Bend of the Columbia River, these give place to the term Cariboo Mountains.

---

* See "Manual of Provincial Information, British Columbia."

In average altitude these mountains are not greatly inferior to the Rockies; their lofty summits rise from 8,000 to 9,000 feet above the sea. The average width of the Rocky Mountain range is about 60 miles, while that of the Selkirks is about 80 miles. From the southern boundary line to the western base of the Rocky Mountains as far as the northern limits of the Selkirks, there is a valley of great length and regularity, extending a distance of over 700 miles, and dividing the two ranges. To the west of these great ranges British Columbia extends into a wide plateau of table land which has been originally elevated some 3,500 feet above the sea level. This plateau has been deeply intersected and eroded by lake and river systems, so that in many places it presents an aspect hardly differing from that of the mountainous regions; in others, however, it opens out into wide plains and rolling ground with comparatively low eminences, affording fine areas of agricultural and grazing land. The entire district has been subject to vast overflows of lava, the disintegrated remains of which the soil is mainly composed. There is a general but very gradual slope of the land from the mountainous country on the southern boundary of the province to the north; notwithstanding this general slope the principal flow of water can find its way southwards through deep fissures penetrating the mountain boundaries on the western and southern sides. This plateau forms the chief agricultural area of the province. The whole of British Columbia south of 52° and east of the Coast Range is a grazing country up to about 3,500 feet, and a farming country up to 2,500 feet where irrigation is possible. The interior plateau is terminated on the west by the Coast Range, a series of massive crystalline rocks of some 6,000 or 7,000 feet in height. This range has a mean width of 100 miles descending to the shores of the Pacific, which is in turn flanked by the submerged Island Range, the tops of which form Vancouver and her adjacent islands, the Queen Charlotte Islands and those of the Alaskan peninsula. One of the most remarkable features of the coast are the fiords and passages, which are analagous to those of Scotland and Norway, and probably surpass those of any part of the world in dimensions and complexity, with perhaps the exception of those in Greenland. The great height of the rugged mountain walls which border them also gives them a grandeur quite their own.* The unique position of British Columbia as a watershed on the Pacific coast of America will be at once recognized when it is understood that all the rivers of great importance on that coast, with the exception of one, the Colorado, rise from within its boundaries. The drainage from its extensive area of mountains and highlands is received into the numerous lakes, thence the surplus is discharged into the few large rivers or their tributaries which finally reach the sea. The principal of these rivers are the Columbia on the south which flows through American territory into the Pacific Ocean, the Fraser River 750 miles long, the Skeena 300 miles long, and the Stikine on the west, the Liard over 300 miles in British Columbia on the north, and the Peace River over 300 miles in British Columbia on the east. These rivers are of great size and volume, and the first four are sufficiently navigable to steamers to form water ways of no small value in the development of the Province.

* Dawson, Geol. Sur. 1884.

The area occupied by the principal lakes of the Province amounts to 2,439 square miles; these are as follows:

NAMES OF LAKES British Columbia	AREA Square Miles
Adams	52
Atlin, part in B.C.	331
Babine	396
Chilco	172
Harrison	122
Kootenay	220
Lower Arrow	64
Okanagan	135
Owikano	98
Quesnel	147
Shuswap	124
Stuart	220
Tacla	135
Tagish, part in B.C.	91
Teslin, " " "	123
Upper Arrow	99
Total	2,439

The submerged mountain range which lies to the west of the mainland is represented by an archipelago of islands, the most prominent being Vancouver and the Queen Charlotte Islands. Of the others, it may be briefly stated that they produce in miniature all the physical features of the larger group.

Vancouver Island may be described geologically as a group of up-turned gneissic rocks embracing certain tertiary areas worn down by glacial action so that in one place extensive gravel moraines, in another beds of boulder clay are to be found, while in a third a regular series of late sand-stones alternate with the barren cliffs of trap. Upon this surface generations of fir trees have flourished, and by their decay have gradually deposited a mould of increasing thickness sufficient to provide ground for other forms of vegetation, until the country has been covered with dense growths of timber, varying according to its situation and adaptability to the wants of each particular kind.

ECONOMIC MINERALS*

The Cordilleran region is, as might be expected from its geological history, a great mineral-bearing belt. In Mexico and the Western States its richness has been amply established, and in Alaska and in Canada it is maintaining this characteristic. Only in the Rockies,

*See "Canada and its Provinces," Vol. IX.—"Physical Basis of Canada," by R. W. Brock, p.p. 53-58.

where the sedimentary rocks of the plains have been recently uplifted and where igneous intrusions are practically absent, and in areas such as some in the interior, where recent strata cover the older mineralized rocks, are deposits of metallic minerals lacking, and in most of these districts the coal resources are quite as valuable.

Only a small portion of the region has been prospected with definite results, so that an account of its resources cannot be attempted, but enough is known to justify sanguine expectations, and to render difficult a concise statement of the modes of occurrences of the minerals.

The Rockies and adjoining foot hills are, as has been mentioned, pre-eminently coal-bearing. Rich coal basins have been delimited from the boundary-line to beyond Yellowhead Pass, and coal is known to continue on northward. Some clay iron-stones are found in these strata, and, in the Livingston range, beds of iron that appear to be indurated iron sands; some argentiferous galena occurs at Field, near one of the few igneous intrusions.

The Selkirk Mountains are characterized by silver-lead and gold occurrences. The Columbia Mountains and the Interior Plateaus are gold-copper bearing, and the newer rocks, at intervals up to and in the Yukon, are coal bearing. The Coast Range batholith has not been found mineral-bearing, but along its entire extent the intruded strata on either side, wherever favorable for mineral deposition, are characterized by gold-copper and sometimes silver-lead occurrences, and in places by iron ores. The Cretaceous rocks of Vancouver Island and Queen Charlotte are coal bearing. Placer-gold districts, sometimes of extraordinary richness, have been found from the Klondike in the north to the international boundary line, particularly where the gravels of the old Tertiary rivers have escaped erosion, or have been captured by the present day streams.

Placer gold in the Cariboo district first called attention to British Columbia. The rich ground was found where the present streams cut through old Tertiary channels. Following the Cariboo the Cassiar field was discovered. Since then Dease Lake, Omenica, Big Bend of the Columbia, Wild Horse Creek, Granite Creek, Atlin and Klondike have been the better known placer fields. The latter, which has produced approximately $250,000,000, is situated in an unglaciated region, and the old weathered Tertiary gravels, "the White Channel gravels," and present streams, where they have trenches through the White Channel deposits, are still being worked on a large scale.

While the bulk of the gold obtained from the Cordillera has been placer, in latter years lode gold has been of equal importance. The greater part of the lode gold is derived from the gold-copper deposits of Rossland, the boundary district, and the Coast; but in the Nelson district, and at Hedley, deposits are worked for gold alone, and some of the silver-lead deposits, as those of Lardeau, are gold-bearing. The gold veins are usually quartz veins carrying pyrite, chalcopyrite, galena, and zincblende, sometimes tetrahedrite and silver minerals, and gold, both free and confined.

The nickel-plate deposit at Hedley is peculiar. It is a contact metamorphic deposit in sediments, cut by sheet-like bodies of dioritic rocks that have altered the sedimentaries to garnet, epidote, calcite, etc., mineralized by mispickel and only relatively small amounts of iron and copper sulphides, hematite, etc.

The commonest types of copper-gold deposit to which belong the boundary district, and most of the Interior Plateau deposits, and most of those situated near the Coast Range, both along the island contact as at White Horse, Yukon, and on the coast are contact metamorphic deposits, in which garnet, hornblende, epidote, etc., are developed in the country rock, with magnetite, often forming bodies large enough to constitute an iron ore, hematite and iron-copper sulphides, of which chalcopyrite is the commonest, though bornite occurs in this way on Texada Island. Sometimes pyrrhotite largely takes the place of iron oxide.

The gold-copper deposits of Rossland and some other points form a type of deposit transitional between contact metamorphic deposits and replacement vein deposits. The ore consists largely of pyrrhotite and chalcopyrite with small amounts of magnetite.

Practically all the copper ores mined carry some gold values. Up to the present copper mining has been restricted to Southern British Columbia Rossland, the boundary and the coast districts of Howe Sound, Vancouver Island, Texada Island, etc. – but now some attention is being paid to the north, and promising deposits are being opened up on Observatory Inlet.

Almost all the lead produced in Canada comes from mines situated in the Selkirk system. The largest producer has been the St. Eugene, near Moyie, East Kootenay. The ore occurs in two parallel fissures connected by cross veins in the pre-Cambrian quartzite. The largest ore bodies are found where a cross vein enters a main vein. The ore consists of argentiferous galena and zincblende with some pyrite. The Sullivan and North Star mines also have large shoots. These East Kootenay deposits resemble those of the Cœur d'Alene to the south.

The Slocan district between Kootenay and Slocan Lakes is another producer. The deposits occur in fissure veins having gangues of quartz, calcite and siderite. The ores are made up of argentiferous galena, blende, tetrahedrite, copper and iron pyrites, arsenopyrite, argentite, ruby silver, native silver and gold. The shoots as a rule are not so large as those of East Kootenay, but the veins are more numerous, and in silver content much higher. Silver-lead veins also occur south of Nelson, as on Sheep Creek and the north fork of the Salmon River. Development work has been done on silver-lead deposits on the Skeena River, near Hazelton, and on Windy Arm in the Yukon.

Platinum occurs with gold in many of the placer districts, and has been produced in limited quantity in the Tulameen district. Native platinum has also been found in this district in a serpentinized basic igneous rock, accompanied by microscopic diamonds.

Mercury has been found in the form of cinnabar, in irregular veins of calcite and quartz that traverse Tertiary volcanics and also impregnating sandstone on Copper Creek, Kamloops Lake. It has been noted in hematite, east of Kootenay Lake, and quicksilver is reported from Field.

While iron ores occur at many points, notably on the coast, no iron industry has so far been developed.

Coal is one of the most important mineral products of the Cordillera. In its occurrences it is well distributed throughout the entire length of the belt in Canada. The coals are mainly bituminous, and by far the greater number are Cretaceous in age. The Carboniferous region in the west is not coal-bearing, for, while in the eastern half of the continent conditions in Carboniferous times favored coal formation, in the western half of the continent the Carboniferous was a period of deep marine or volcanic conditions, and the favorable shallow-water conditions do not begin until the Cretaceous period.

Coals of Tertiary age, some of excellent quality, though most of them are lignites, occur at a number of points, as in the Nicola Valley, Princeton and in the Yukon.

While coal is known at many points, and no doubt occurs in the North in numerous basins in the great central region between the Coast Range and the Rockies, the main production is from the coal measures of Vancouver Island, and the Rockies and foot hills in the south-eastern portion of the Cordilleran belt. On Vancouver Island the productive measures occur in the upper part of the Cretaceous, and are worked near Nanaimo and Comox. In the Rockies and foothills there are three coal horizons. The lowest and most important is the Kootenay formation of the Lower Cretaceous, in which are the Crow's Nest, Blairmore-Frank and Cascade basins. A second group of the productive measures is the Belly River, situated towards the top of the Upper Cretaceous column; while the third is the Edmonton of Laramie age. The two latter, as was noted above, are also coal-producing on the plains. The basins within the mountains are usually Kootenay formation while those of the foothills are generally Belly River or Edmonton. The amount of coal in some of the basins is enormous. The southern Elk River basin, for example, has twenty-two workable seams aggregating 216 feet in thickness. The basins have been traced as far as the Athabasca River, but are known to continue northward.

While the coals are mostly bituminous, at a few points they become anthracitic. On the main line of the Canadian Pacific Railway at Bankhead, the only mine at present producing anthracite in Canada, and at Anthracite, in the Cascade basin, the coal is of this quality. Anthracite also occurs locally in Queen Charlotte Island. At the head-waters of the Skeena River, the Ground Hog district, at present being prospected, contains anthracite coal.

Excellent stones for building purposes are found throughout the region. Marble of high quality is produced near Lardeau and on the coast. Cement materials occur at various points and support industries at the eastern edge of the Rockies and on Vancouver Island.

Clays suitable for brick-making occur in many of the valleys, and at Clayburn, near Mission, a good fire-clay is being utilized.

CLIMATE

The climate* of the Pacific coast is mild and equable. Situated at the base of the Coast Range, where the moisture-laden winds from the Pacific must rise to cross the mountains and thus become mechanically chilled and unable to retain their load of water vapour, it naturally has a very heavy precipitation, generally exceeding a hundred inches, but varying greatly from point to point, according to distance from the mountains. From May to

* See page 68, "Canada and its Provinces," Vol. IX.

September is usually comparatively dry. The interior plateau has a very different climate. The winds from the Pacific have been deprived of moisture on the western slope of the Coast Range, and are mechanically heated descending to the plateau region, and hence rendered susceptible to absorbing moisture. The climate is consequently dry. The annual range of temperature is great, as is also the daily range in summer. Chinook winds—hot, dry winds—prevail. In crossing the high Selkirks the winds are deprived of moisture in the same manner as in crossing the Coast Range. The precipitation is, in consequence, heavy, particularly the snow fall, which on some of the mountains is almost incredibly great. The Rockies are drier, and on the eastern slopes somewhat resemble the interior plateau.

The climates of districts in the northern Cordilleran region do not differ markedly from those of areas in the south similarly situated with respect to the great mountain systems, except that the winter temperatures become gradually lower. Dawson, in the Yukon, about latitude 64° N, has a hot, dry summer. In the long 20 to 22 hour days vegetation matures with extraordinary rapidity, so that most grains and vegetables may be grown.

Table showing rainfall, snowfall, total precipitation, lowest, highest, and mean temperature for the year 1912 at various pla[illegible]s in British Columbia:—

Place	Rainfall	Snowfall	Total Precip.	Highest Temp.	Lowest Temp.	Mean Temp.
Agassiz	76.14	16.50	77.79	92.0	12.0	49.32
Alberni	64.25	23.25	68.45	96.0	10.0	48.67
Atlin	4.38	35.80	7.96	72.5	34.0	33.08
Barkerville	15.87	143.60	30.23	82.0	28.0	35.43
Chilcotin (Big Creek)	12.46	14.50	13.91	88.0	31.0	37.21
Clayoquot	117.18	none	117.18	85.0	25.0	49.34
Chilliwack	51.22	36.00	54.82	92.0	2.0	49.10
Cranbrook	9.58	26.00	12.18	96.0	26.0	41.07
Glacier	22.25	457.00	67.95	87.0	13.0	35.66
Hedley	10.64	19.54	12.59	100.0	12.0	46.01
Holbe[illegible]	126.11	none	126.11	85.0	23.0	47.96

Place	Rainfall	Snowfall	Total Precip.	Highest Temp.	Lowest Temp.	Mean Temp.
Ikeda Bay	75.61	4.00	76.01	73.0	26.0	49.5
Kamloops	11.59	18.75	13.47	101.0	18.0	45.6
New Westminster.	55.54	19.90	57.53	90.4	13.6	49.4
Nelson	23.11	74.50	30.56	100.0	4.0	45.4
Penticton	10.92	8.80	11.80	90.0	1.0	46.7
Prince Rupert	87.95	20.60	90.02	85.0	8.0	46.7
Quesnel	8.48	21.50	10.63	95.0	31.0	40.5
Revelstoke	29.42	146.50	44.07	95.0	17.0	43.7
Salmon Arm	14.41	38.56	18.27	97.0	15.0	44.1
Swanson Bay	149.44	65.25	155.08	85.0	12.0	46.1
Summerland	11.89	29.30	14.82	96.0	7.0	45.6
Vancouver	56.12	9.25	57.05	85.1	15.8	49.7
Vernon	11.45	33.00	14.75	96.0	18.0	44.8
Victoria	29.53	3.20	29.85	89.8	23.5	50.3

WATER POWERS OF THE PROVINCE

THE development of hydro-electric plants on a fairly large scale began in Britis Columbia as early as 1897. The first plants of any magnitude were those at Bonning ton Falls on the Kootenay River, near Nelson, B.C., and the Goldstream plant of th British Columbia Electric Railway on Vancouver Island. These plants were und construction simultaneously, but the Bonnington Falls plant can claim priority as was placed in operation early in 1898, while the Goldstream plant was first operated i September of the same year. Since that date large plants have been installed for the pr duction of electrical energy for the cities of Victoria and Vancouver, and for the manufa ture of pulp, and in the mining industry. The following is a list of some of the princip developed water powers which will be described in detail later:—

CAPACITY OF THE PRINCIPAL WATER POWERS AS AT PRESENT DEVELOPED IN THE PROVINCE OF BRITISH COLUMBIA

Owner	Situation	Present capacity installed Horse Power	Purpose for which Energy is utilized
West Kootenay Power & Light Co., Limited	Kootenay River and Kettle River, near Nelson	23,000	Mining, smelting, light and industrial power
British Columbia Electric Railway Co., Limited	Goldstream, near Victoria	3,000	Light, industrial power and street railways
British Columbia Electric Railway Co., Limited	Lake Buntzen, Burrard Inlet	84,500	Light, industrial power and street railways
Western Canada Power Co., Limited	Stave Lake, near Ruskin	26,000	Industrial power (26,000 H.P. now being added)
British Columbia Electric Railway Co., Limited	Jordan River, Vancouver Island	25,000	Light, industrial power and street railways
Ocean Falls Co., Limited	Link River, Ocean Falls	11,200	Wood pulp and lumber manufacture
Canadian Collieries (Dunsmuir) Limited	Puntledge River, near Nanaimo	9,400	Coal mining
Power River Co., Limited	Powell River	24,000	News print paper manufacture
Granby Consolidated Mining, Smelting & Power Co., Limited	Falls Creek, Granby Bay	7,325	Copper mining and smelting
City of Nelson	Kootenay River, near Nelson	4,000	Mining, industrial power and light
City of Kamloops	Barriere River, near Nelson	2,800	Light and industrial power
Britannia Mining & Smelting Co., Limited	Britannia Creek, Howe Sound	2,735	Copper mining and reduction
Hedley Gold Mining Company	Similkameen River, near Hedley	2,650	Gold mining
City of Prince Rupert	Woodworth Lake, near Prince Rupert	1,650	Light and industrial power
Swanson Bay Forests, Wood Pulp & Lumber Mills, Limited	Swanson Bay	1,250	Wood pulp and lumber manufacture
City of Revelstoke	Illicilliwaet River, near Revelstoke	600	Light and industrial power
Other small developments described hereafter		690	Mining, municipal and hotel lighting, salmon canning
	TOTAL HORSE POWER AT PRESENT INSTALLED	230,000	

Estimates have been made by the writer as the result of careful exploration work t within reasonable distance of the cities of Vancouver and Victoria there are possibili of the economic development of water powers aggregating 750,000 H.P These wa powers are all situated within an area of 20,000 square miles, thus representing 37½ H for each square mile of territory. Outside of this area a rough estimate of the water po possibilities of the Province would bring this figure up to 3,000,000 H.P., or nearly equa the estimate for Ontario, and in the writer's opinion this amount is conservative, altho until much further investigations have been made, such an estimate is merely an intellig guess.

The capitalist and manufacturer seeking for opportunities of developing new indust will find a fertile field in British Columbia for utilizing these water powers in additior their use in supplying electrical energy for cities and towns. Already large Portla cement plants using about 8,000 H.P. of electrical energy are in operation on Vancou Island, paper pulp is being manufactured on a large scale, and smelting plants are be operated by water-powers.

In view of the value of these water-powers it might be useful to refer to some of more important uses to which they may be applied.

In the field of pulp manufacture, Canada is a great paper making country, and following figures indicate to what extent:—

	Tons per Annum	Value	24 hou Horse Po required
Mechanical Pulp	800,000	$12,400,000	210,00
Chemical pulp	272,000	10,336,000	7,50
News paper	480,000	18,240,000	20,00
Total	1,552,000	40,976,000	237,50

Of that output British Columbia at the present time produces in value about 8 Bearing in mind the vast forests in the Province, and in many places the existence of la water powers in close proximity to unlimited areas of spruce, hemlock and balsam fr which the fibre is produced, that industry alone is an inviting one. It is, however, in field of electric-chemistry that some of the greatest opportunities are offered, but in electro-chemical industries it must be borne in mind that the construction of hydro-elect plants must be carried out, so as to produce electrical energy as economically as is done the large plants in Norway, Sweden, and Switzerland. In British Columbia, howev there are in many of the water-powers somewhat similar conditions to those that obtain Scandinavian territory, i.e., powers that can be developed economically under high hea In the writer's opinion, excluding the cost of transmission lines, many of these includi some low head plants, can be developed as complete installations from $60 to $100 p horse power, and those powers nearer the lower figure make them an economical possibility for successfully undertaking electro-chemical industries. Considering this fact together with the wonderful possibilities of transport by water freight to the markets, the advantages in competing with less favorable districts is obvious.

In the utilization of atmospheric nitrogen for the production of nitric acid and the manufacture of nitrates, great developments have taken place during the last decade in Norway and Sweden;* an original small plant established in Norway of 25 H.P. in 1903 has now grown so rapidly that water-power amounting to 400,000 H.P. is used at the present time in its production. The world's consumption of nitrogen in its various combinations is about 750,000 tons, representing a value of $250,000,000, with a yearly increase in the demand of 5% or 6%. Four-fifths of this supply has been produced hitherto from Chili saltpetre. This natural saltpetre contains from 18% to 60% of nitrogen, but it is well known that at the present rate of consumption these fields are rapidly becoming exhausted. This great source of the world's fertilizers, which in 1870 yielded 147,000 tons per annum now yields over three million tons per annum. With the exhaustion of these fields the fixation of atmospheric nitrogen has become a great national duty in every country possessing economical means of producing these fertilizers. In 1898 Sir William Crookes, the great British chemist, sounded a note of warning in his address before the British Association when he said:—

"The fixation of nitrogen is a question of the not distant future. Unless we can class it among certainties to come, the great Caucasian race will cease to be the foremost in the world and will be squeezed out of existence by races to whom wheaten bread is not the staff of life."

That problem which for so long has been the dream of chemists had, however, not long to wait for its solution, and in 1902 a plant was erected at Niagara Falls by the Atmospheric Products Company. From this small beginning has developed a great industry with unlimited possibilities for the future.

At the present rate that the consumption of fertilizers is increasing, in less than five years it will reach the great total of 6,000,000 tons per annum and on the basis of six-tenths of a ton per H.P., this represents 10,000,000 H.P. to manufacture this quantity. Apart, however, from the exhaustion of the Chilian fields, it is possible for British Columbia to compete seriously in the world's markets in the industry in competition with the natural saltpetre.

The principal method† used for extracting nitrogen from the atmosphere is by heating the air in an electric furnace to a temperature of 3,000 degrees Centigrade, when some of the oxygen combines with the nitrogen, forming oxides of nitrogen. These gases coming from the furnace are cooled and led through water, which absorbs the nitrogen oxides and forms nitric acid. The nitric acid is then utilized as the base for the manufacture of the

* See "Utilization of Atmospheric Nitrogen," by T. H. Norton, U. S. Bureau of Manufactures.

† See "Fixation of Nitrogen from the Air," by B. Thomas, Seattle, 1913.

following, among other products: fertilizers, explosives, dyes, pyrotechnics, match photographic chemicals, etc., and is used for assaying and in gold extraction, etc.

Fertilizers are manufactured in the form of calcium nitrates, by a solution of limesto in nitric acid, or the direct leading of the gases from the furnaces over slaked lime. It a well known fact that the soil demands the nitrogen extracted from it by the plant to returned in the form of manure Of the well known fertilizers, nitrate of lime as produc by the Norway plants, has been found to be the most economical. They contain abo 13% of nitrogen in the most active form and 25% to 30% of lime in a soluble conditio The nitrogen being in a readily soluble form is distributed quickly through the soil a thus comes at once within reach of the plant roots. It is assimilated by the plants witho having first to undergo transformations in the soil as in the case of sulphate of ammor and almost all other compounds of nitrogenous substances. In Canada with its gre agricultural farm lands the market will in the future be an unlimited one, and in t meantime British Columbia ports are excellently placed for the shipment of fertilisers an all water route through the Panama Canal to Europe.

The enormous use of explosives in British Columbia for logging, quarrying, railwa construction and public works, will make the future demand for this commodity mu greater than in the past, and as the base of all explosives is nitric acid, it will be realiz that a great local market will be available for utilising their manufacture.

The manufacture of calcium carbide is the oldest of the electro-chemical industries Canada. It is obtained by causing quicklime to react on coke at the temperature of t electric arc; its principal use is in the production of acetylene gas, and also for the productio of calcium cynide for nitrogenous fertilisers. At present in eastern Canada there are plan utilising 14,000 H.P. and producing 12,000 tons per annum, half of which is exported. British Columbia is favourably situated for this industry with all the raw materials abundance, there are opportunities in this field for profitable investment. The calciu carbide industry* originated in Canada with Mr. Wilson of Ottawa as one of the pioneer and there are now 70 plants in different parts of the world absorbing 360,000 H.P. for i production. In 1910 the world's production was 250,000 tons, which had increased 340,000 tons in 1913; it will be seen that there is also a great future for the enterprise capital in this industry.

In the field of electro-metallurgical work probably few countries in the world hav greater promise for its development and the opportunities for the use of electric smelters i a country so rich in mineral resources is unbounded. The reader is referred for informatio on this subject to an interesting paper on "The Electric Furnace in Metallurgical Work" published by the U. S. Bureau of Mines, as it is impossible to do more than refer to th possibilities here. The establishment of electric metallurgical refineries for copper in th

* See paper, "Making our Water Powers Valuable," by Arthur Surveyer, M. Can. Soc. C.E., Proc Can. Soc. C.E., 1914.

† See Bulletin No. 77, Washington, Government Printing Office, 1914.
See also Bulletin 67, "Electric Furnaces for Making Iron & Steel," 1913.

neighborhood of Vancouver or Prince Rupert where the plants could be erected on excellent water front sites at the minimum of expense, would add to the incentive already existing to develop further the great copper mines of the province. The application, too, of electric power in dealing with the rich zinc, lead and magnetite ores obviously offer a great field of expansion.

EXISTING WATER POWER PLANTS IN PROVINCE

THE WEST KOOTENAY POWER & LIGHT COMPANY, LIMITED POWER DEVELOPMENTS ON THE KOOTENAY AND KETTLE RIVERS

IN 1897, the Kootenay Power & Light Company commenced the construction of a hydro-electric plant at Lower Bonnington Falls. At that time a small smelter was in operation at Trail, and mining work was in progress at Rossland, 32 miles from the site of the proposed hydro-electric plant, but the total amount of energy utilized at Trail and Rossland did not exceed 1,000 H.P. The proposed hydro-electric plant, now known as Bonnington Falls Plant No. 1, was constructed with a capacity of 4,000 H.P., and at a later date Bonnington Falls Plant No. 2 was built and units aggregating 16,000 H.P. were installed in order to provide for the increased load which developed far in excess of the demand anticipated when Plant No. 1 was built.

In the year 1907, the load on the system had still further increased, particularly in the "Boundary Country", and in order to provide adequate service to consumers in this district, the 3,000 H.P. plant of the Cascade Water Power & Light Company was taken over by the Kootenay Power & Light Company.

In 1907, the gold and copper mining industry in the Kootenay Country was practically undeveloped and the load at Rossland was only about 600 H.P. To-day light and power is being supplied to the many mining, smelting and refining companies near Rossland, the connected load in this vicinity alone having increased from 600 H.P. to 6,200 H.P. This great development of the mining and allied industries has been greatly assisted by the supply of power at reasonable rates by the Kootenay Power & Light Company. At the present time, the Company has installed hydro-electric units aggregating 23,000 H.P., with provision in No. 2 Power House of space for two additional units.

The West Kootenay Power and Light Company Limited, owns and operates three hydro-electric generating plants on the Kootenay and Kettle Rivers. These are the largest and most important developments in the interior of British Columbia, and furnish power and light to the cities of Trail, Rossland Grand Forks, Phœnix, Greenwood, Boundary Falls, and other municipalities within the radius of their transmission lines.

Kootenay River Development. Lower Bonnington Falls.

Kootenay River Development. Upper Bonnington Falls.

In this section of British Columbia the mines and smelters are the largest consumers of power.

KOOTENAY RIVER GENERATING STATIONS

The Kootenay River Plants are situated at Bonnington Falls about 11 miles below the City of Nelson.

The total length of the Kootenay River is about 350 miles, and the area of the watershed is 9,800 square miles. Practically the whole drainage area lies in high mountainous country, and the snowfall is heavy; the flow of water in the river depends almost entirely on the melting snow. The minimum flow at Bonnington Falls is 5,850 cu. ft. per sec., and occurs during the months of January and February. The maximum flow of 60,000 cu. ft. per sec. occurs during June and July, when the snow is melting most rapidly. About 9 miles above Bonnington Falls the Kootenay River emerges from Kootenay Lake, which is about 75 miles long with an average width of about 3 miles; it forms a splendid natural reservoir, which tends to equalize the flow in the river below the Lake.

BONNINGTON FALLS PLANT No. 1

This plant is situated at Lower Bonnington Falls and has a capacity of 4,000 H.P. under a normal working head of 34 feet.

The equipment consists of one unit of 2,000 H.P., and two units each of 1,000 H.P. The turbines are of the horizontal Victor type, and are provided with cylindrical gates.

Kootenay River Development. Bonnington Falls Plant No. 1 at Lower Bonnington Falls.

Kootenay River Development. General View of Upper Bonnington Falls.

Kootenay River Development. No. 1 Plant, Lower Bonnington Falls.

Each turbine consists of two runners one right hand and one left hand. On each of the turbine shafts is mounted one 3 phase, 60 cycle, 1100 volt Canadian General Electric generator. The units run at a speed of 180 revolutions per minute.

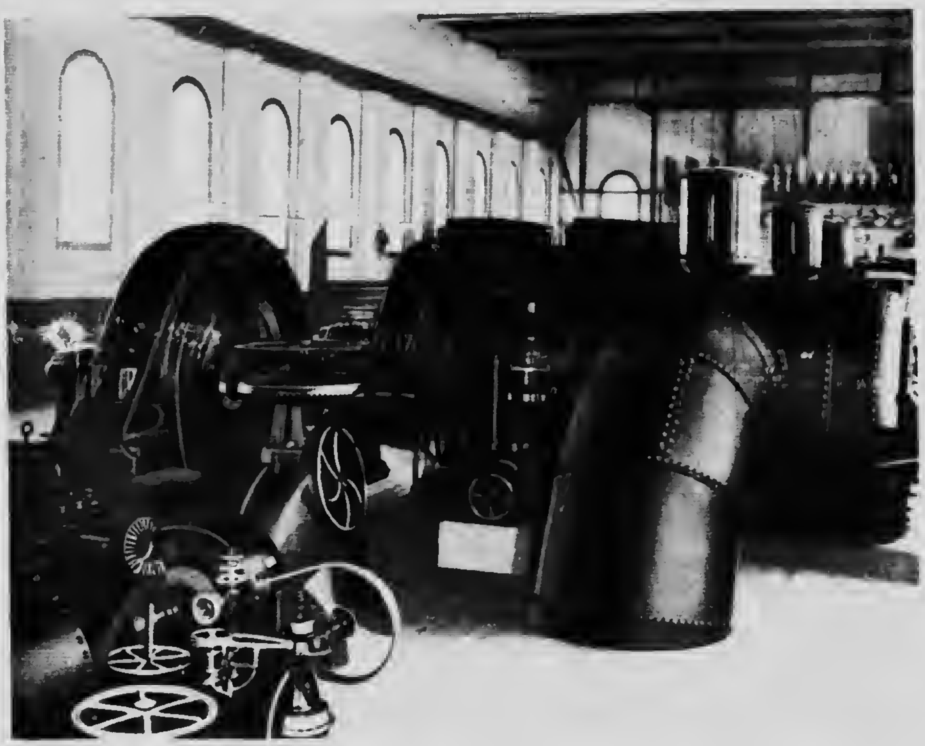
Four banks of Canadian General Electric air blast transformers are provided for stepping the voltage up from 1,100 to 22,000, at which potential it is transmitted. The capacity of the transformers is 1,000 H.P. per bank.

BONNINGTON FALLS PLANT No. 2

Plant No. 2 is located at Upper Bonnington Falls, about one mile above Plant No. 1.

The power house is built in the channel immediately below the falls on the north side of the river. The building and the intake structure form a wing dam which diverts the water into the turbine penstocks. The power house and intake structure are of monolithic concrete construction, reinforced with round rods and steel rails.

Water enters the turbine flumes between the concrete intake piers and can be shut off by means of gates and stop-logs operated by an electrically driven overhead travelling



Kootenay River Development. Interior of Generator Room, Plant No. 1, Lower Bonnington Falls.

winch. The trash racks are placed in the flumes behind the intake gates and are accessibl for inspection or repairs.

The natural head of water above the tailrace level is 63 feet at low water stage, bu during high water the head is reduced to 56 feet. This difference in head is caused by th contracted area of the channel a short distance below the Falls. When the load demand it, the Company will remove the obstructions in the channel and increase the sectional are to such an extent that the water level below the Falls will be lowered about 5 feet at hig stages of the river. A low dam will also be built across the river above the falls which wil

Kootenay River Development. No. 2 Plant and City of Nelson Plant, Upper Bonnington Falls.

raise the head at high stages of the river and thus equalize the head between the extreme of high and low water. This work will increase the working head to 70 feet.

Space is provided in the building for four main generating units, two exciter units, an for all transformer and switching apparatus to complete the plant. At present, two unit are installed. A 30 ton electrically operated overhead travelling crane spans the mai generator room, and railroad cars can be brought into the power house on a spur trac under the crane.

The generating equipment of No. 2 Power House consists of two 5,625 K.V.A., 3 phase, 60 cycle, Canadian General Electric "Umbrella" type generators, each driven direct by on 8,000 H.P. "Francis" turbine, at a speed of 180 R.P.M. Two vertical shaft turbine driven exciter sets are provided which are capable of exciting the entire generator equipment when installed.

Each of the main units is driven by three inward flow "Francis" turbine runners mounted on vertical shafts. The upper and intermediate runners discharge in opposite directions into one common draft tube, the upper one discharging downwards. The lower runner also discharges downwards, but into a separate draft tube. These draft tubes are moulded in the concrete and are joined together at the lower end, forming one common discharge. No steel lining is used in the draft tubes.

The thrust bearing is made up of two discs. The lower disc is supported by a ball seat and the upper one is held in place by an adjustable nut on the shaft. Oil is forced between the discs under a pressure of 150 lbs. per square inch.

The governor pressure pumps and governors are located in a chamber beneath the main floor of the building, the only machinery on the main floor being the generators, exciters and switch-boards.

The present transformer equipment consists of three banks of three 1,875 K.V.A. oil insulated, water cooled transformers, which step the voltage up from 2,200 to 60,000. There is also provided one bank of three 1,250 K.V.A. transformers, which step the voltage

Kootenay River Development. Head Works, No. 2 Power House. Upper Bonnington Falls.

Kootenay River Development, Bonnington Falls. Front View, No. 2 Power House, Upper Bonnington Fa

Kootenay River Development. Generator Room, No. 2 Plant, Upper Bonnington Falls.

Kootenay River Development. Interior View of Generator Room, No. 2 Power House, Upper Bonnington Falls.

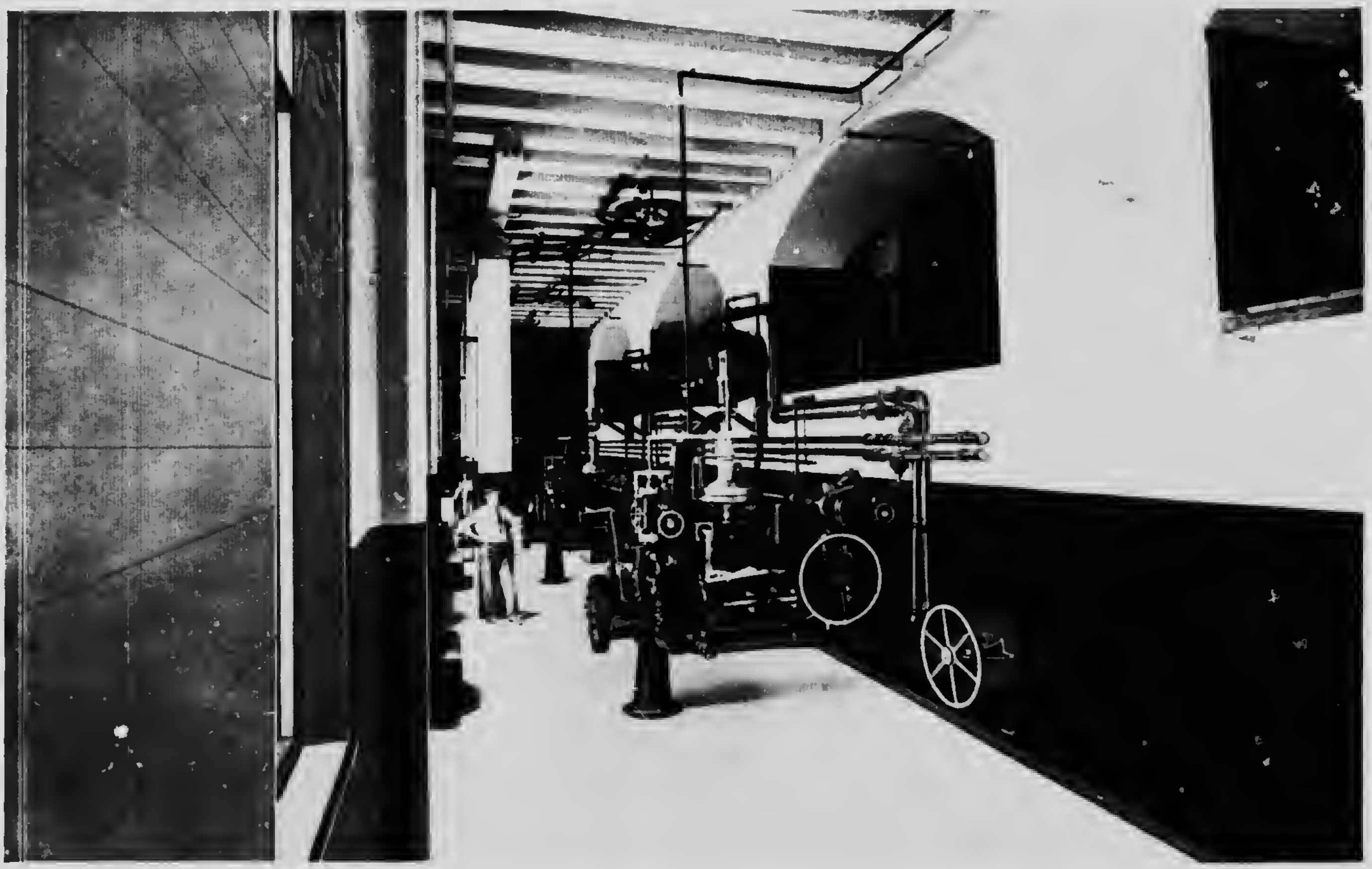
up from 2,200 to 22,000; this last bank may be paralleled with the transformers at P
No. 1, and is used for supplying power to Rossland, Trail and Nelson.

All of the 2,200, 22,000 and 60,000 volt switches are electrically controlled from
benchboard which is situated in front of the instrument panels on the switchboard gal

TRANSMISSION LINES

From Bonnington Falls, Plants Nos. 1 and 2, current is transmitted at 22,000 volt
Rossland, Trail, Nelson and Silver King Mine, where substations are provided. The lon
distance over which current at this voltage is transmitted is 32 miles. From Plant N

Kootenay River Development. Thrust Bearing of one of the Main Units.
No. 2 Power House, Upper Bonnington Falls.



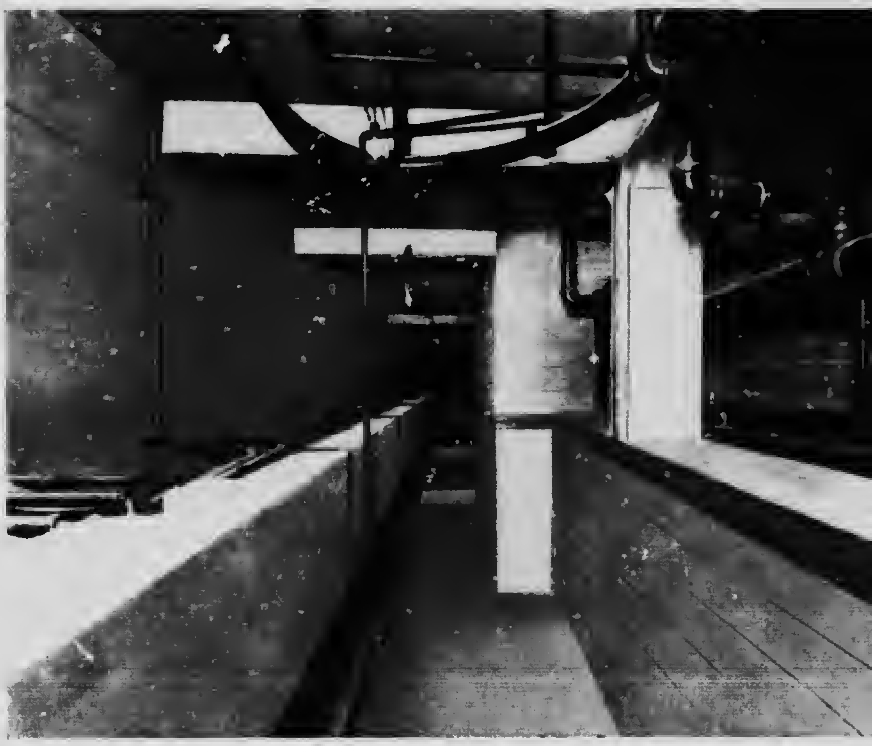
Kootenay River Development. Pump Chamber. No. 2 Power House, Upper Bonnington Falls.

current at 60,000 volts is transn.itted a distance of 81 miles to Greenwood Substation, to substations at Rossland, Grand Forks, Phœnix, and Boundary Falls Substation, w is 84 miles from Bonnington Falls.

KETTLE RIVER PLANT

The Kettle River Plant, known as No. 3 Plant or Cascade Plant of the West Koot Power and Light Company, is located on the Kettle River in the "Boundary Distr about 12 miles below the town of Grand Forks.

About half a mile above the power house the river enters a gorge and forms a seri falls and rapids providing a natural head of 120 feet. This head has been increased by construction of a dam at the gorge entrance which raises the water level 36 feet, givi static head of 156 feet at the power house. From the dam the water is conveycd in 700 of open rock cut and 400 feet of tunnel to the pipe line intake, thence to the power hou a steel pipe 7 feet in diameter.



Kootenay River Development. Pipe Tunnel showing Cable Ducts and Transformer Piping, Power House No. 2.

ubstation, and
station, which

Vest Kootenay
ary District,"

rms a series of
creased by the
feet, giving a
yed in 700 feet
power house in

Piping,

Kootenay River Development. 20,000 and 60,000 Volt Switch and Lightning Arrester Compartment, No. 2 Power House.

The generating equipment of No. 3 Plant consists of three 750 K.V.A., 3 phase, 60 c 2,200 volt Canadian Westinghouse generators, each direct connected to turbines of H.P. capacity. The turbines are made up of two 39 inch runners on a horizontal shaft are controlled by Escher Wyss mechanical governors. The speed of the main units is revolutions per minute. Two 45 K.W. exciters running at 1,100 revolutions per mi provide current for excitation purposes.

Current is stepped up from 2,200 to 22,000 volts by means of three banks of three K.W. transformers, at which voltage it is transmitted to substations at Grand Fo Phœnix, Greenwood and Boundary Falls, the latter substation being 28 miles dis from No. 3 Plant.

GOLDSTREAM HYDRO-ELECTRIC DEVELOPMENT OF THE BRITISH COLUMBIA ELECTRIC RAILWAY COMPANY, LIMIT VICTORIA, B. C.

PRIOR to the year 1898, the City of Victoria, Vancouver Island, was supplied light and power by the Steam Plant of the British Columbia Electric Rai Company, Limited, situated within the City Limits.

In September, 1897, an agreement was made with the Esquimalt Water Works Comp Limited, for the supply of a maximum and minimum daily amount of water to the Br

British Columbia Electric Railway Company, Limited. Goldstream Power House.

Columbia Electric Railway Company, Limited, for a hydro-electric plant to be built at Goldstream, about 12 miles from Victoria, wherein it was stipulated that all water supplied for power purposes would be returned to the Water Works Company's reservoir below the Power House site, and in suitable condition for domestic purposes in Victoria.

The Esquimalt Water Works Company's storage reservoirs at Goldstream are five in number, and are at elevations of 1,200 to 1,500 feet above see level. From the storage reservoirs, the water flows to a balancing reservoir at El. 1,100, the storage capacity of which is about 3,500,000 cubic feet, thence to a lower reservoir at El. 450.

In 1898, Goldstream Power House was built by the British Columbia Electric Railway Company, Limited. The Power House is of brick on concrete foundations, and

British Columbia Electric Railway Company, Limited. Generator Room, Goldstream Power House.

is situated near the west bank of the lower reservoir, the available static head at the water wheels being 650 feet.

The initial installation consisted of two 350 K.W., 3 phase, 60 cycle, 700 volt generators each direct connected to Pelton water wheels of 600 horse power; these units were placed in operation in September, 1898, and superceded the Steam Plant in Victoria.

Water is conveyed from the Water Works Company's balancing reservoir at El. 1,100 to Goldstream Power House through a steel pipe line 8,000 feet in length, made up of 4,000 feet of 33 inch pipe and 4,000 feet of 30 inch pipe. After leaving the tail races, the water passes over two measuring weirs, and is discharged into the lower reservoir.

British Columbia Electric Railway Company, Limited. One of the older Water Wheels in Compartme with Pipe ' ' r separated from Generator Room, Goldstream Power House.

British Columbia Electric Railway Company, Limited. Transformer and Switch Room, Goldstream Power House.

In 1903, Goldstream Power House was enlarged, and a third unit of 500 K.W. capacity was installed; in 1905, a fourth unit was added of 1,000 K.W. capacity direct driven by two water wheels each of 1,000 horse power.

Current is generated at 700 volts, and by means of air-cooled transformers it is stepped up to 17,500 volts, at which it is transmitted over a two circuit single pole transmission line to Victoria, twelve miles distant, where it is received at Rock Bay Substation along with energy from the Vancouver Island Power Company's plants at Jordan River and Brentwood Bay.

THE COQUITLAM-BUNTZEN HYDRO-ELECTRIC DEVELOPMENT OF THE BRITISH COLUMBIA ELECTRIC RAILWAY COMPANY, LIMITED

THE Coquitlam-Buntzen Hydro-Electric power scheme for the supply of electrical energy to the City of Vancouver and the Municipalities of the lower Mainland of British Columbia, is owned and operated by the Vancouver Power Company, a Company incorporated under the provisions of the "Water Clauses Consolidation Act, 1897," of the Statutes of British Columbia, and a subsidiary Company of the British Columbia Electric Railway Company, Limited, which controls the electric railway, light and power systems in the cities of Vancouver, New Westminster, Victoria and the

Coquitlam-Buntzen Development. Looking Northward, Coquitlam Lake.

Coquitlam-Buntzen Development. Coquitlam Dam.

surrounding districts. The growth of the district supplied during the decade 1900-10 shown by the census returns is indicated by an increase in the population from 41,000 175,000, or nearly 330 per cent. The estimated population within the area of supply now approximately 200,000 persons.

Prior to the year 1903 the requirements of the district were served by a small ste plant, but by the active signs of growth that were in evidence at that time, it was necess to make provision for an entirely new plant to meet the requirements of the develop territory, and the utilization of Lakes Coquitlam and Buntzen for power purposes decided upon in that year.

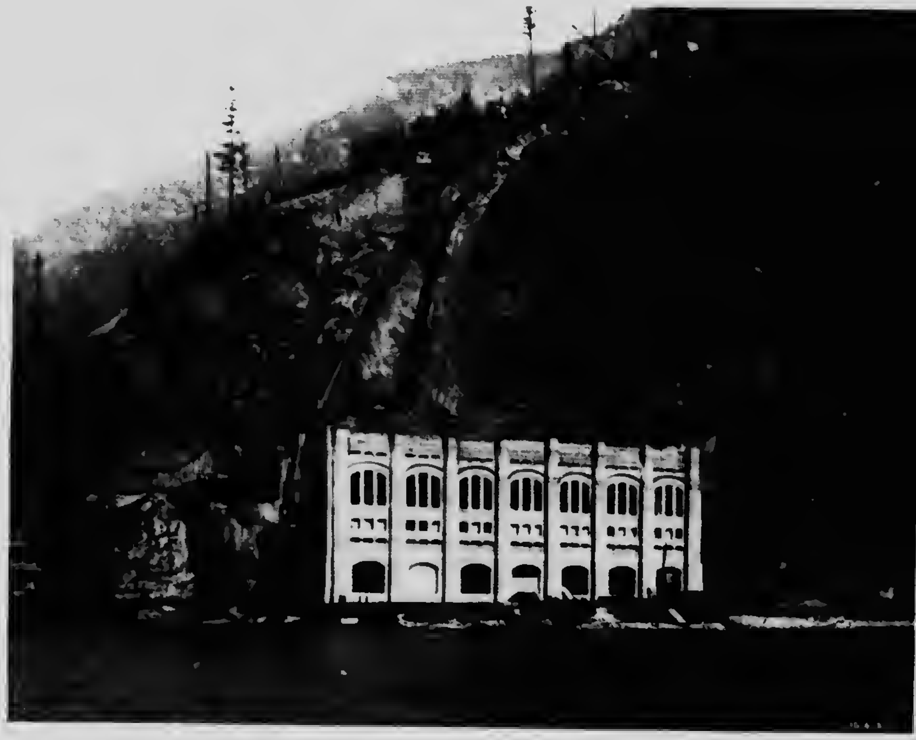
ORIGINAL DEVELOPMENT

The original Coquitlam-Buntzen scheme comprised the raising of the surface Coquitlam Lake by means of a small rock filled crib dam with crest 443 feet above sea lev and delivering the water so stored through a tunnel 2¼ miles long to Lake Buntzen small lake due west of Coquitlam Lake, and thence through steel pipes to a power house the shore of Burrard Inlet, an arm of the sea. By the construction of a concrete dam at the north end of Lake Buntzen, an ideal forebay reservoir was obtained.

ULTIMATE DEVELOPMENT

When the original tunnel was designed it was thought that ample provision had been made for any increased demand for water which might occur on account of extensions to Plant No. 1, Lake Buntzen, but the rapid development and growth of the district around Vancouver soon made it evident that the demand for power would in a very short time exceed the maximum capacity of the tunnel. After careful investigation it was decided that the existing development could be considerably enlarged so as to utilize almost the entire run-off of the Coquitlam watershed. The enlargement of the Coquitlam-Buntzen tunnel, and the construction of a dam to increase the storage capacity of Coquitlam Lake was therefore decided upon; extensions were also carried out at the Power House. By the time the enlargement of the tunnel had been completed, June 1911, the rate of growth of the Company's load was such that the construction of an entirely new plant at Lake Buntzen was decided upon. The preliminary work for this new plant was commenced in the autumn of that year, and the first unit in Power House No. 2 was placed in operation in October, 1913.

Coquitlam-Buntzen Development. Old Crib Dam, Coquitlam Lake.



Coquitlam-Buntzen Development. Front view, Power House No. 2, Lake Buntzen.

COQUITLAM LAKE

This Lake, which is the main storage reservoir of the scheme, is situated in Townships 4, 5 and 6, Range 6, West of the 7th Meridian, in the Province of British Columbia. The Lake is about seven miles in length, with an average width of about one-third of a mile. Its average summer level prior to the building of the small crib dam at its outlet was about 432 feet above sea level, and its original area about 2,190 acres. The area of the watershed is approximately 105 square miles, and the mountains rise precipitously on either side to a height varying from 3,000 feet to 6,000 feet. The greater part of the water-shed is well covered with heavy timber, chiefly cedar and hemlock, with some fir and spruce.

The precipitation over the watershed for the last eleven years has averaged 153 inches. The winter snows over the watershed are heavy and remain on the higher peaks until late in the summer.

The following is a record of the precipitation at Coquitlam Lake for the years 1903 to 1914.

COQUITLAM LAKE, B.C.

PRECIPITATION.

ESTIMATED DRAINAGE AREA 105 SQUARE MILES.

	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
January	18.48	28.81	13.25	26.50	12.38	16.80	15.50	32.41	21.59	21.71	15.90	26.51
February	5.21	21.16	16.91	18.66	16.93	15.45	23.03	15.78	10.12	15.48	10 40	9.54
March	8.67	22.30	23.36	6.60	10.35	21.98	10.46	7.16	9.66	2.13	11.94	10 00
April	9.34	7 23	4 50	4.41	15.74	13 50	3.07	8.61	5.63	9.97	7.56	6.92
May	7 78	6.14	4.61	13.21	5.20	9.20	12.62	6.95	9.62	3.75	9.59	4 71
June	7.30	3.53	3 16	12.08	3.92	3.49	3.90	5.14	4.34	5.59	8.21	5.26
July	3.55	5 10	......	1.18	2.45	3.62	4.69	0.25	1.45	2.66	3.78	0.57
August	2 68	1 05	......	3.04	5.15	4.34	8.60	4.43	2.21	9.55	3.04	1.30
September	17 47	5 82	50 00	28 53	8 98	7.24	7.51	5.01	9.54	6.72	8.14	13.85
October	17 88	10.41	......	31.99	4.28	20.31	21.21	21.49	5.45	13.61	14.43	20.27
November	33.10	25.02	10 62	22 78	37 09	33 75	37.29	28 77	29.48	29.28	26 09	25.37
December	14.75	20 00	18.07	20.89	24.78	21.12	12.02	23.62	22.96	26.69	11.64	5 28
TOTALS	146 21	156 57	144 48	189 87	147.25	170 80	159.90	159 62	132.05	147.14	130.72	129 58

Coquitlam-Buntzen Development. View taken from East Side of spillway showing Coquitlam Dam in construction. The trestle work carries the flume

ORIGINAL DAM, COQUITLAM LAKE

The original dam was built across the Coquitlam River a little below the outlet of the lake. It is a rock filled crib structure of the over-flow type, 170 feet in length, with the crest 443 feet above sea level and about 11 feet above the original level of the lake. It is 113 feet in length along the crest, and 9 feet of free board is provided.

NEW COQUITLAM DAM

The precipitation and run-off records of Coquitlam Lake showed that in order to utilize the entire run-off from the watershed, a dam to raise the level of the lake another 60 feet was required. The site of the new dam at Coquitlam Lake is a little below the old crib dam, now buried in the upper toe of the new one. A dam of th[illegible]aulic fill type with heavy rock toes was decided upon owing to the impracticability [illegible]g a satisfactory foundation for a masonry dam, as bedrock was only revealed on [illegible]rtion of the site.

The new dam is built upon a natural barrier formed at the outlet of the lake by a receding glacier, and is formed of fine blue and grey glacial boulder clays together with interstratified layers of cemented gravel and boulders.

The new dam was built with its crest at El. 518 and with spillway at El. 503. The maximum height of the dam above the lowest point of foundation on the centre line is 100 feet; the extreme width at the base is 655 feet, and the length along the crest including

Coquitlam-Buntzen Development. General view of Coquitlam Dam with water flowing over the spillway.

the spillway is 1,200 feet. The slope of the upstream face is 1 in 5, and of the down-stream face 1 in 2 to 1 in 4. The width of the spillway is 250 feet, with 15 feet of free board, which provides spillway capacity considerably in excess of any recorded flood. The construction of the new dam provided storage amounting to 180,500 acre feet available for power purposes.

The total quantity of material in the dam amounts to 544,710 cubic yards. Of this quantity, 116,360 cubic yards consists of rock placed in the toes by hand and by cableways; the remainder of the material in the dam is sluiced material.

Coquitlam-Buntzen Development. Intake Valve House, Plant No. 2, Lake Buntzen.

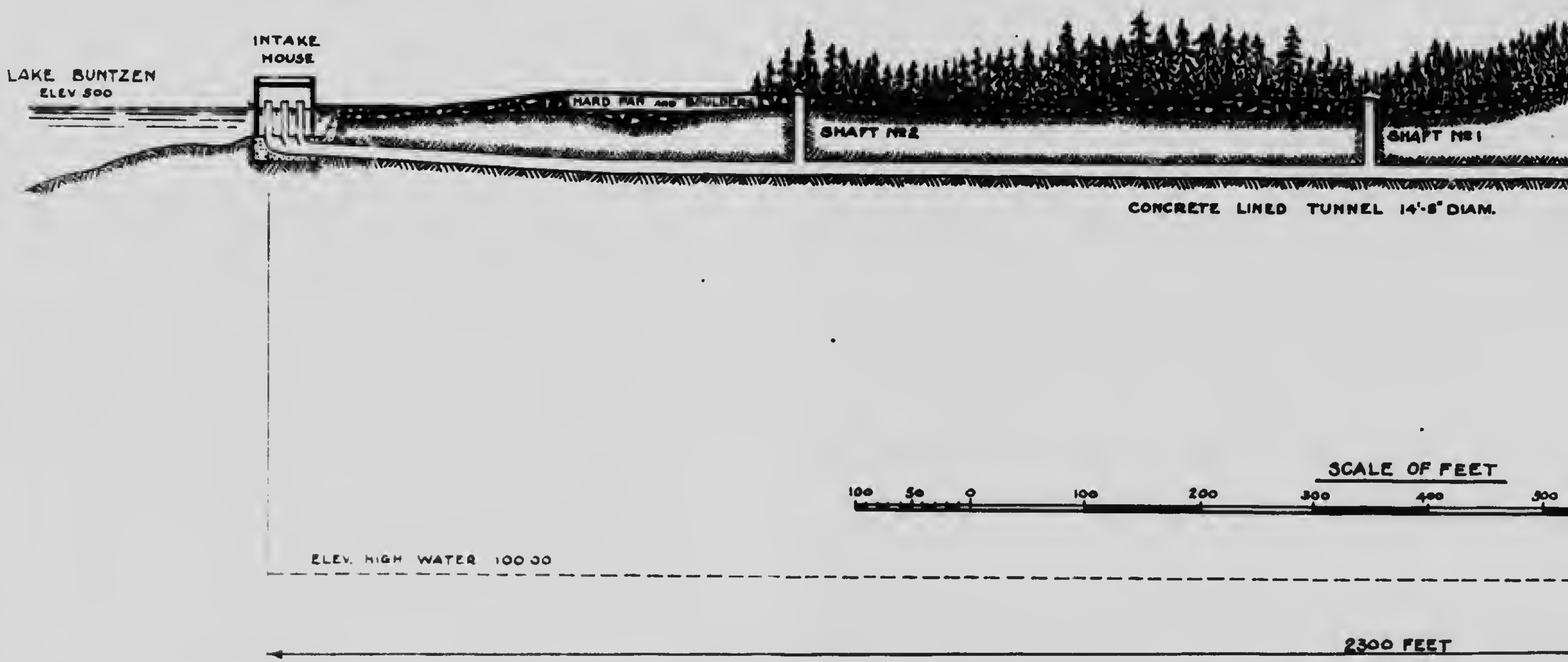
During the construction of the dam the outflow from the lake was carried around the dam site in a tunnel driven under the spillway. This tunnel has an area of 412 square feet and is 490 feet in length; it was designed to carry 12,000 cubic feet per second. For controlling the flow of water through this tunnel, permanent gates are placed in a concrete tower at its upper end.

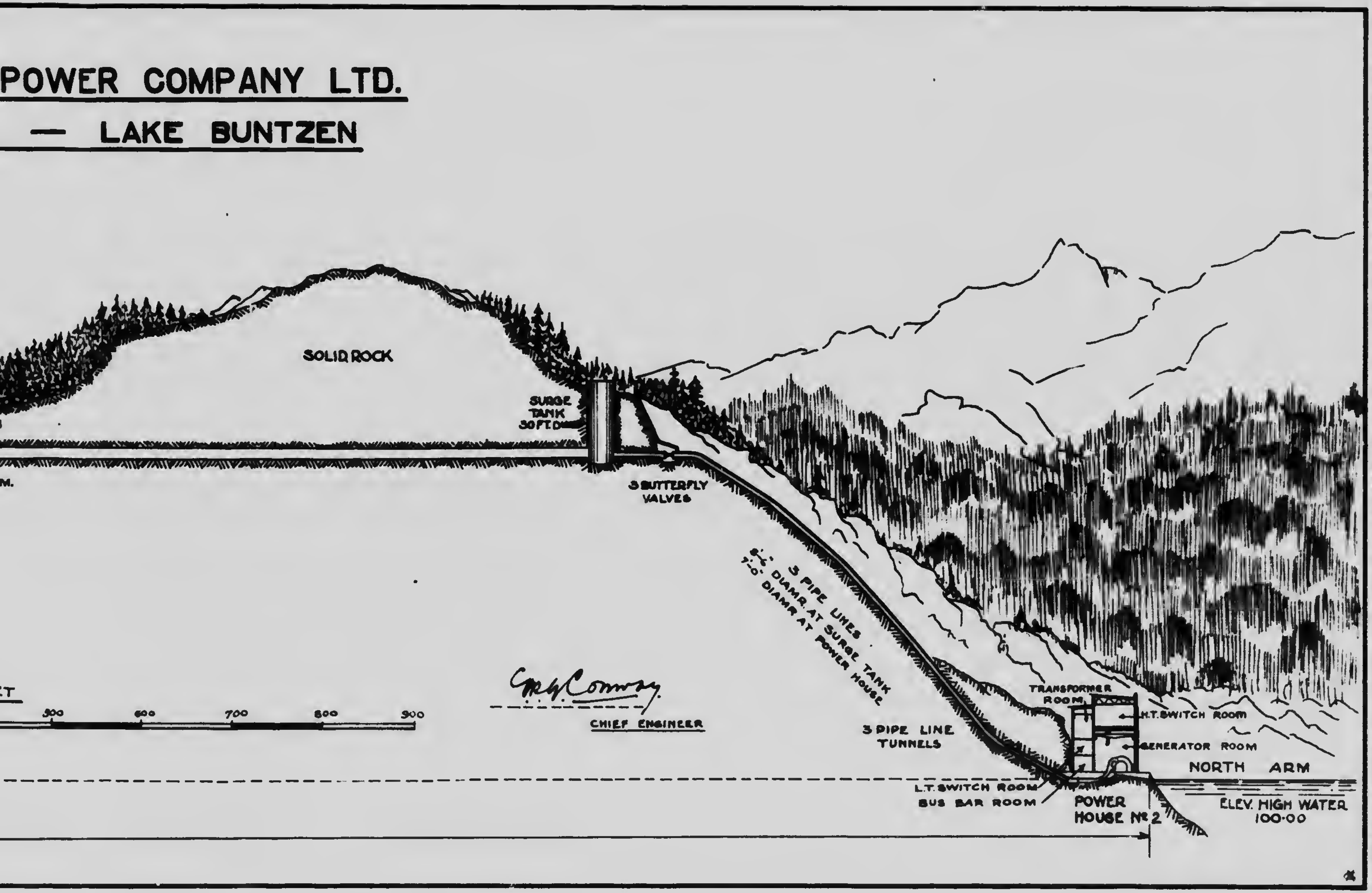
As the City of New Westminster had drawn its water supply from Coquitlam Lake since 1892, and as the raising of the lake level rendered the original intake works useless, an entirely new intake for the New Westminster Water Works had to be provided. The new intake structure is a substantial concrete tower founded on bedrock on the east side of the lake, about 1,000 feet north of the dam. The tower is circular in plan, with an inside diameter of 18 feet. In the walls of the tower four intake openings are provided, which are protected by screens and controlled by means of gates placed within the tower. A

Coquitlam-Buntzen Development. Plant No. 1. Lake Buntzen.

VANCOUVER POW

PLANT №2 —




POWER COMPANY LTD.
— LAKE BUNTZEN
SOLID ROCK
SURGE TANK 30 FT. D.
3 BUTTERFLY VALVES
3 PIPE LINES
DIAMR. AT SURGE TANK
7'-0" DIAMR. AT POWER HOUSE
3 PIPE LINE TUNNELS
TRANSFORMER ROOM
H.T. SWITCH ROOM
GENERATOR ROOM
NORTH ARM
L.T. SWITCH ROOM
BUS BAR ROOM
POWER HOUSE No 2
ELEV. HIGH WATER 100·00
500
600
700
800
900
CHIEF ENGINEER

secondary intake is placed within the tower, so designed that water may be drawn off at any desired elevation.

From the intake tower the water enters a tunnel about 2,000 feet in length, which passes under the spillway and also under the sluice tunnel. The lower end of the tunnel is connected by means of a pipe line, with a distributing chamber from which the water supply mains for New Westminster emerge. For the protection of the New Westminster water supply, extensive clearing operations were carried out along the shores of the Lake.

COQUITLAM-BUNTZEN TUNNEL

The total length of the tunnel which conveys water from Coquitlam Lake to Lake Buntzen is 12,650 feet. This work was begun in 1902 and completed in 1903. A square section about 9 feet by 9 feet with rounded corners was adopted, and it was designed to carry 500 cubic feet per second.

The enlargement of this tunnel formed part of the programme in connection with the extension of the Lake Buntzen Plant. The section of the tunnel was increased to 192 square feet, which is sufficient for the ultimate development of the Coquitlam-Buntzen scheme. The work of enlargement was completed in June, 1911.

The intake of the Coquitlam-Buntzen Tunnel was rebuilt when the new dam was constructed; it consists of a heavy masonry retaining wall founded on bedrock and built against the steep hill above the tunnel entrance. This entrance is protected by a trash rack 41 feet wide and 35 feet high, supported by heavy steel cables and counterbalanced,

Coquitlam-Buntzen Development. Intake Valve House, Plant No. 2, looking towards Lake Buntzen.

Coquitlam-Buntzen Development. Top of pipe line grade showing No. 1 pipe line with standpipe. Plant No. 2, Lake Buntzen.

so that it can readily be raised and cleaned. Two independent sets of head ga are provided for controlling the flow of water through the tunnel. One of these gates of the Coffin type 9 feet in diameter; the second set consists of two Stoney sluice ga placed side by side. The operating gear for both sets of gates is placed in chambers cut the face of the mountain well above high water level; the gates are arranged for operat either by gasoline engine or by hand.

LAKE BUNTZEN STORAGE RESERVOIR

Lake Buntzen lies immediately to the west of Coquitlam Lake, from which it separated by a range of mountains which reach an elevation of 4,000 feet.

The precipitation at Lake Buntzen, during the last eleven years, is shown on accompanying able. The average rainfall during this period was 112.53 inches.

LAKE BUNTZEN, B.C.

PRECIPITATION.

DRAINAGE AREA 7 SQUARE MILES.

	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
January	18.89	20.66	14.10	21.44	16.40	12.52	13.17	8.20	10.10	15.94	17.38	19.29
February	5.20	13.61	11.23	11.45	13.86	9.68	10.09	12.03	6.44	10.13	8.89	7.82
March	6.90	11.46	15.72	2.57	7.25	17.12	5.69	11.38	9.41	3.02	9.28	8.04
April	7.37	5.18	5.34	2.39	10.10	8.07	5.51	12.01	2.26	6.74	5.28	5.08
May	6.32	3.80	6.02	10.32	2.46	5.85	6.69	4.54	9.18	3.23	7.31	3.38
June	5.58	3.05	4.30	8.94	3.02	2.70	4.52	4.02	2.99	4.62	6.37	4.69
July	3.33	3.30	2.12	0.79	1.61	3.50	3.64	0.25	1.03	2.58	3.48	0.80
August	2.30	1.08	1.85	1.79	3.38	0.30	6.26	5.92	1.39	8.25	2.44	1.13
September	15.26	5.25	20.69	24.05	6.75	5.65	4.85	3.27	10.10	4.74	6.25	10.99
October	16.26	7.29	9.40	24.57	1.34	13.81	14.30	15.62	3.65	11.40	10.44	15.25
November	24.19	20.93	9.21	14.95	25.98	24.64	22.63	19.51	20.45	19.08	21.26	18.90
December	9.85	13.73	16.16	14.35	14.44	8.33	7.59	17.75	21.60	19.04	8.53	3.59
TOTALS	121.44	109.34	116.14	137.61	106.59	112.17	105.75	114.50	98.60	108.77	106.91	98.96

Coquitlam-Buntzen Development. Surge tank, showing openings for pipe line connections.

The area of Lak Buntzen is about 50 acres, and the drainag area about 7 squar miles. By the construct ion of a concrete dam 5 feet in height and 36 feet long on the crest, a excellent forebay wa provided. The elevatio of the crest of Lak Buntzen Dam is 400 fee above sea level. Te outlets, 54 inches i diameter, with the neces sary trash racks an hand operated hea gates, were provided fo the connection of pip lines which convey wat to Power House No. and two openings 2 inches in diameter wer provided for the excite pipe lines.

PLANT No. 1, LAK BUNTZEN

The original pow house known as Lak Buntzen Power Hous No. 1, is situated on the east shore of Burrard Inlet about 16 miles from the City o Vancouver.

The Power House is built of hewn granite, the main floor being 5 feet above high wate The original installation has been added to from time to time, and the present equipment as follows:

4–1,500 K.W. Westinghouse Generators driven by Pelton Water Wheels.
1–5,000 K.W. Canadian General Electric Generator driven by Pelton Water Wheels.
1–5,000 K.W. Dick Kerr Generator driven by Doble Water Wheels.
1 5,000 K.W. Canadian General Electric Generator driven by Doble Water Wheels.

All of the above units are of the horizontal type, the water wheels and generator being in all cases mounted on the same shaft.

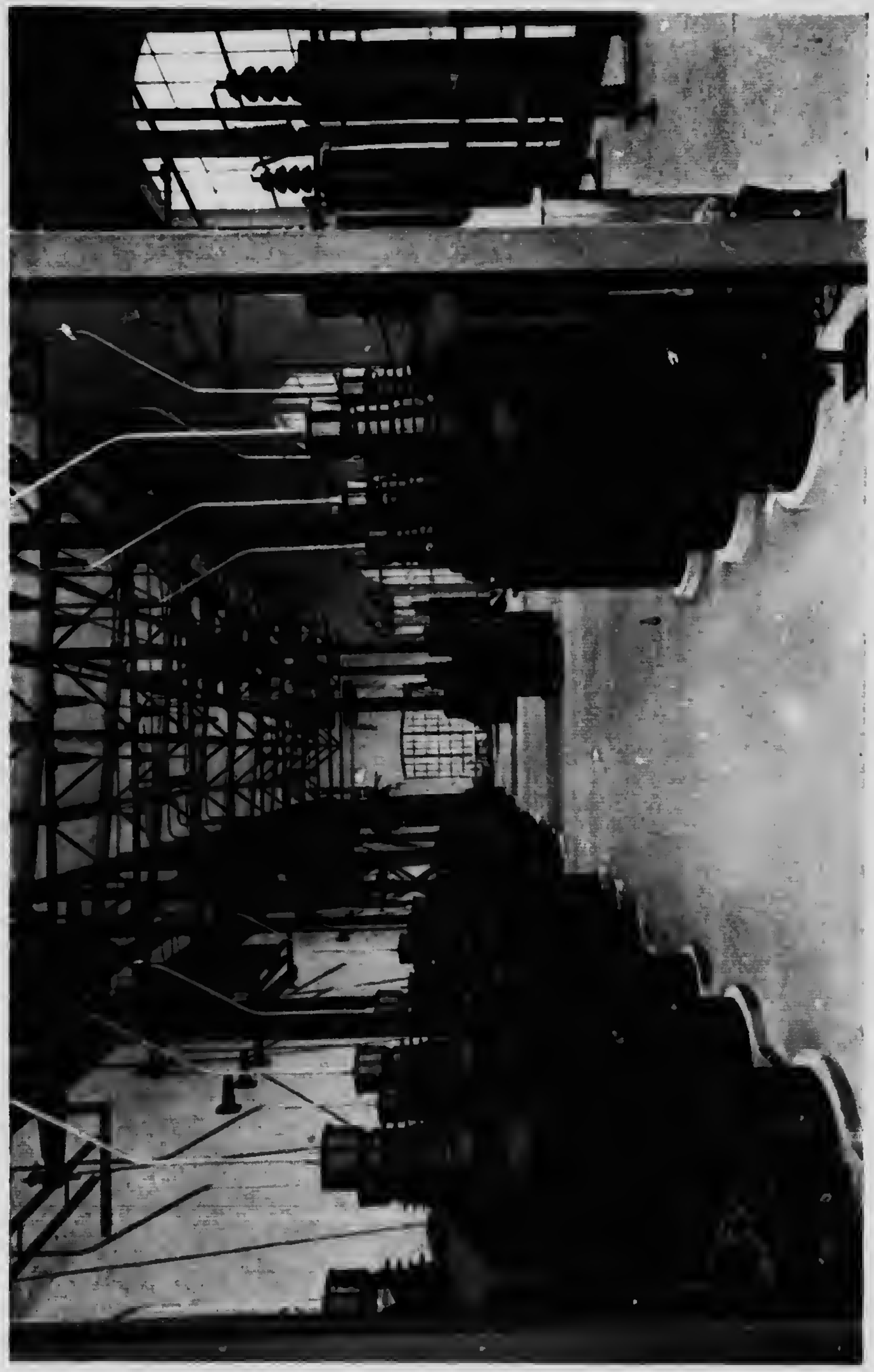
In addition to the above equipment, four exciter units are provided.

All of the generators are of the three phase, 60 cycle type generating current at 2,200 volts. For regulation purposes Tirrill regulators are provided.

The generating equipment is installed on the main floor of the Power House, 5 feet above high water level. The operating bench board and switch board are placed on the gallery along the back wall of the generating room. Behind the switchboard the generator switches are situated and on the floor above these are placed the low tension transformer switches.

The transformers and high tension switching equipment are housed in a separate building behind the Power House. The transformer equipment consists of three banks of three 3,000 K.V.A., single-phase, oil insulated, water cooled transformers which step up the voltage from 2,200 to 34,600. This voltage will be increased to 60,000 at an early date. Electrolytic lightning arresters are placed in concrete shelters on the roof of the building. The high tension switches are of the K-15 type and are placed in a separate room behind the transformer compartments. All of the equipment in the Transformer House was supplied by the Canadian General Electric Company.

Coquitlam-Buntzen Development. Pipe Lines Nos. 1, 2 and 3. Plant No. 2, Lake Buntzen.



Each of the 1,500 K.W. units in Power House No. 1 is supplied with water from Lake Buntzen by means of a pipe line 48 inches in diameter and 2,000 feet in length. Two pipe lines 60 inches in diameter are provided for the fifth unit. One pipe line 84 inches in diameter at the upper end and tapering to 72 inches in diameter at the Power House, is provided for the sixth unit, and a similar pipe line provides water for No. 7 unit.

In the original installation the first 800 feet of the pipe lines below Lake Buntzen Dam were of wood stave construction. The wood stave portions of these pipe lines have now been replaced with pipes of rivetted steel.

PLANT No. 2, LAKE BUNTZEN

In the autumn of 1911, the installation of additional machines at Lake Buntzen was decided upon, and as it was impracticable to build further extensions to Power House No. 1, a new power house site was found about one-third of a mile to the south of the original power house. The work undertaken in connection with Plant No. 2 comprises the construction of a reinforced concrete power house containing water wheels of a total capacity of 40,000

Coquitlam-Buntzen Development. Replacing wood stave pipe lines with riveted steel pipes.

Coquitlam-Buntzen Development.
Transformer Room, Power House No. 2, Lake Buntzen.

H.P., generators and transformers, together with the necessary high and low tension switching equipment. Water for driving the units is obtained from Lake Buntzen through a concrete lined pressure tunnel 14 feet 8 inches internal diameter and about 1,800 feet long, driven through solid rock and controlled by three Doble needle intake valves placed with their seats on a concrete foundation on the bottom of Lake Buntzen. An outer cylinder is provided which may be lowered down to a horizontal seat, thus excluding water from the needle valves so that they may be inspected without the use of a diver. These needle valves are operated by means of oil pressure.

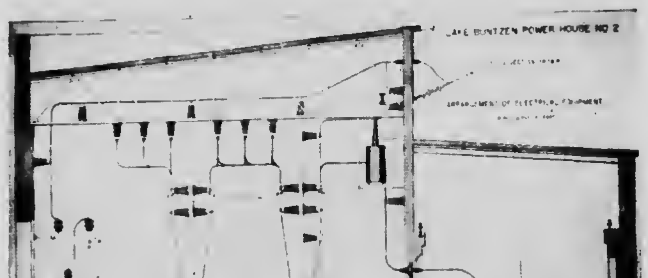
Near the lower end of the pressure tunnel and close to the top of the hill, a steel surge tank 30 feet in diameter is provided, and from this point the water is conducted to Power House No. 2 through three steel pipe lines. Close to the surge tank a Pelton Doble Venturi butterfly valve is installed in each pipe line. The pipe lines are connected to the surge tank by means of flanged reinforcing plates. The pipe lines are 8 feet 6 inches in diameter and ½ inch thick at their upper ends, tapering to a diameter of 7 feet at the Power House, where the thickness is 1⅛ inches. About 200 feet from the Power House the pipe lines pass into tunnels driven through rock. The pipe line grades are very steep, the slopes ranging from 28 to 53 degrees, thus rendering difficult the handling of the large pipe sections.

Power House No. 2 is built on solid rock and is of reinforced concrete construction. The design of the building was carefully studied from an architectural point of view, and its massive proportions harmonize with the precipitous mountains which form the background.

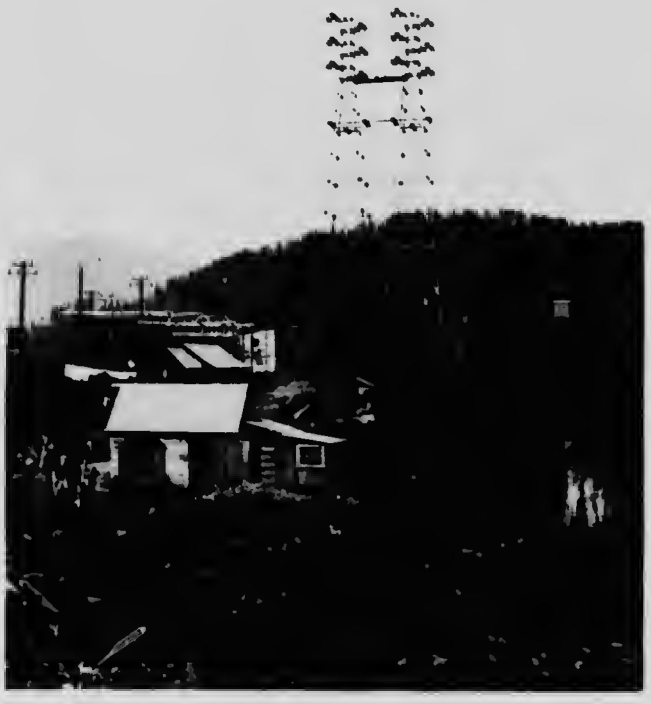
On the main floor of the building, which is 5 feet above high water level, three units of a total capacity of 40,500 H.P. are installed. Each unit consists of one Dick Kerr 8,900 K.V.A., 3 phase, 60 cycle generator of the revolving field type, generating current at 2,200 volts, direct driven at a speed of 200 revolutions per minute by four Pelton Doble water wheels, the combined capacity of which is 13,500 H.P. The generator and four water wheels are all pressed on to a hollow nickel steel shaft 51 feet 3 inches long, forged in one piece. A separate pipe line is provided between the surge tank and the power house for supplying water to each unit. Close to the back wall of the power house this pipe line divides into four branches, each branch supplying water to one wheel of the unit; on each branch a Doble hydraulically operated gate valve is provided which controls the admission of water to the two nozzles which direct the water on to the buckets of each wheel.

The speed regulation of each unit is controlled by a Lombard Governor which opens and closes the main nozzles according to the load on the unit, through links attached to a rocker-shaft.

Each unit is also provided with two Pelton-Doble auxiliary relief water economising nozzles. Should the load on the unit fall off suddenly, these two relief nozzles are opened by the action of the governor as the main nozzles are closed, thereby avoid



Coquitlam-Buntzen Development. Cross Section of No. 2 Power House.



Coquitlam-Buntzen Development.
South Tower, Barnet Crossing, Buntzen-Vancouver Transmission Line.

ing any sudden change of velocity in the pipe line. The relief nozzles are closed slowly by means of springs, and water hammer in the pipe lines is thus reduced to any desired extent and wastage of water is minimized.

For excitation purposes, three 300 K.W., exciter units are provided, one of which is placed at the rear of each main unit. Each exciter is composed of a Dick Kerr induction motor-generator set direct driven by one Pelton Doble water wheel mounted on one end of the shaft.

The bus bars are placed in cells in the bus bar room at the level of the main floor, and the voltage is controlled by Tirrill Regulators. The low tension generator and transformer switches, which are of the Canadian General Electric H-6 type, are placed in the low tension switchroom situated above the bus bar compartments. The transformer room is situated immediately above the low tension switchroom, and the equipment consists of four banks of three 3,000 K.V.A., single phase, oil insulated, water-cooled transformers, by means of which the voltage is raised from 2,200 to 34,600, to be increased at an early date to 60,000 volts. The high tension switchroom, which also contains the lightning arrester equipment, is situated above the generator room; the high tension switches are of the Canadian General Electric K-15 type. All of the low tension and high tension switches are electrically controlled from the operating bench board which is situated on the operating gallery in the generator room.

All of the switches, switchboard equipment, and transformers were supplied by the Canadian General Electric Company.

Two 50 ton electrically operated travelling cranes control the entire length of the generator room, and one 25 ton electric crane is provided in the transformer room.

TRANSMISSION LINES

The electrical energy generated at Lake Buntzen is transmitted at 34,600 volts to substations at Vancouver and to other substations in the territory served by the Company, by two 2-circuit transmission lines. Two of these circuits, which are connected in at Plant No. 1, are carried on wooden poles; the other two circuits are outgoing lines from Plant No. 2, and are carried on steel towers. A tie line connects Power Houses Nos. 1 and 2.

STAVE FALLS DEVELOPMENT OF THE WESTERN CANADA POWER COMPANY, LIMITED

THE Western Canada Power Company, Limited, was formed in 1909 for the purpose of supplying power for industrial purposes in Vancouver and the vicinity so as to encourage the establishment of factories, and in sufficient quantity to meet any demand that the growth of Vancouver may develop.

In June, 1909, the Company took over the property and franchises of the Stave Lake Power Company, Limited, which had secured a charter from the government of the Province of British Columbia, giving it the right to develop power on the Stave River, and to distribute power over the whole of the district surrounding Vancouver, and had also secured franchises for the sale of power for industrial purposes in Vancouver and New Westminster.

The Stave Lake Power Company had in the course of several years previous to 1909, done a considerable amount of preliminary work at the Stave River, including the establishment of a gauging station, the building of roads and camps, and the partial construction of a log sluice dam.

The Western Canada Power Company, Limited, commenced the construction of a 50,000 H.P. power plant in the winter of 1909-1910. The first section of this power house, comprising two units of 9,000 K.W. capacity each, was completed and power was delivered in Vancouver on January 1st, 1912.

The site of the power development is at Stave Falls, about six miles north from the junction of the Stave and Fraser Rivers at Ruskin, B.C., and thirty-five miles east of the City of Vancouver.

The mountains forming the watershed are granite; they rise high above the timber line, and are covered with snow and small glaciers. The upper river is a large glacier-fed stream, and several smaller streams empty into the lake, some coming direct from the glaciers on the high mountains on the west side of the lake.

Stave Falls Development. Stave Lake.

Stave Lake Development. Stave Falls Power House.

The lake is nine miles long and about a mile or more wide. The east and west shores are precipitous, but at the head and foot there are large areas of low-lying land, which are flooded during high water. From the foot of the lake to the Stave Falls the river is seven miles long, about two miles of this having been rapids, with a total fall of 11 feet, the rest being navigable at all stages of the river and having practically no fall. At the falls and the rapids, in the immediate vicinity of Stave Falls, the river drops 80 feet, and then continues on its course over a series of rapids for a distance of four miles, finally debouching through a narrow granite gorge into a tidewater basin, where it joins the Fraser River.

Stave Lake Development. Power House, Stave Lake.

The total fall from the original low water level of the lake to tidewater was 225 feet, and when the dam which has now been constructed, has been increased to its full height, the water will be raised 35 feet above the low water level.

The dam will form a lake extending from Stave Falls to the upper end of Stave Lake, a distance of 18 miles. The area of the lake at the present height of the dam is about 13 square miles, and when the dam is completed to its full height the area will be 24 square miles. This reservoir will have a storage capacity of nearly 370,000 acre feet, which is large enough to store the flood water so that the total mean flow of the river will be made available for the generation of power.

Daily gauge records of the flow have been kept for over six years; during the past three years a careful [illegible] of hydraulic observations have been made, and the mean flow has been found to be 3,5[illegible] cubic feet per second that can be utilized for the purpose of generating power.

Stave Falls Development. Dam and pipe lines at back of Power House.

Stave Falls Development. Dam and spillway.

The total fall from lake to tidewater will eventually be made use of in two power houses; the upper plant, which is now in operation, utilizing 125 feet maximum and 105 feet minimum head, and the lower plant utilizing the balance.

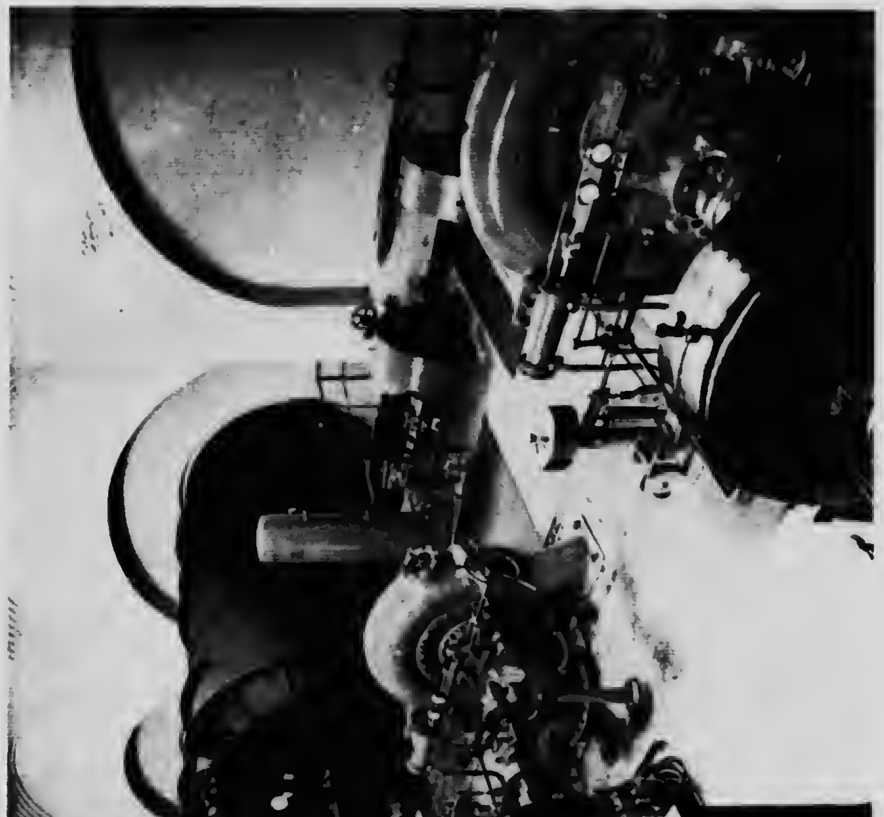
The site for the first development was chosen in the vicinity of Stave Falls; at this point the river is divided into two branches by a rocky island half a mile long, admirably adapted for the construction of forebay and intake works while an old channel known as the Blind Slough, with a rocky bed some 600 feet wide at a higher level than the bed of the existing river, presents a most excellent site for a dam to provide for the flood discharge.

Stave Lake Development. Downstream face of dam.

The second development will consist of a dam 160 feet high at the highest point, built in a narrow gorge to form a reservoir about three miles long, backing the water up to the tailrace of the upper plant. The power house will be located to the east of the dam, with its tailrace on tidewater, within sight of the main line of the Canadian Pacific Railway, and the penstocks for the turbines will be laid in tunnels about 1,600 feet long.

DESCRIPTION OF THE POWER PLANT

The power plant, as it now stands, consists of a sluice dam 40 feet high, provided with five sluice ways 22 feet wide, to take care of the flood discharge; a solid concrete intake dam; two 14 feet 6 inches steel penstocks with provision for two more; a power house with two 10,000 K.W. units and provision for extension for two more, and a tailrace channel 1,500 feet long excavated in the old bed of the river.



The sluice dam, which was partially built by the Stave Lake Power Company, consists of four concrete piers 8 feet wide, with two abutment piers, the spaces between the piers being filled with 24 inch stop-logs, 24 feet long, which can be removed by means of a specially designed electric winch to permit of the passage of flood water.

The intake works consist of a solid concrete dam about 70 feet high at its lowest point, embedded in which are the four steel penstocks which are belled out to 19 feet diameter at their entrance and taper down to 14 feet 6 inches in diameter where they leave the dam. The entrance to these penstocks is closed by steel radial gates, closing an opening approximately 20 feet square, and designed to operate under a maximum head of 45 feet. These gates are operated by electric winches set on the top of the dam. There are also two 42 inch exciter penstocks which are closed by radial gates.

In front of the radial gates are set screens of very large area. No special precautions are taken to protect the screens from ice, as it is a peculiar condition of the Stave River that no ice ever forms, even at times when zero weather obtains for as much as a week. The reason of the non-formation of ice is that there is a large underflow from the forests during the winter months, which raises the temperature of the water.

These dams are at present built to such a height as to store the water about 8 feet above the original low water level of the lake. They are being raised this year (1914) an additional 10 feet and next year they will be extended another 25 feet in height.

The sluice dam which is being carried to its full height, will be made into a solid dam, and will no longer be used for flood discharge.

Stave Lake Development. Looking downstream above dam.

Slave Falls Development. Switchboard, Slave Falls Power House.

The dam which is to be built across the Blind Slough will consist of concrete piers 30 feet high, making 14 sluice-ways, each closed by stop logs, which can be removed by an electric winch. Provision will be made in the design of these sluice-ways, so that a Stoney roller gate can be placed in any of them if it should be advisable, but the operation of the stop logs has proved so economical and successful for handling floods, that it is not likely that more than one of the sluice-ways will be closed by a Stoney gate. The Blind Slough Dam will provide for a maximum discharge of 100,000 cubic feet per second.

The foundations for the power house were excavated in solid rock. The total quantity of rock excavation for the penstocks, power house and tailrace amounted to 75,000 cubic yards.

The tailrace canal is 70 feet wide, and designed to run 10 feet deep when all four units in the power house are in operation. In addition to the rock excavation for the tailrace, some 75,000 cubic yards of sand, clay and boulders were excavated by steam shovel.

Just below the power house a small V-shaped weir was built to hold the water to a proper height to seal the draft tubes. At present the flow of the river is rapid from below the foot of the tailrace, but when the lower plant is built, the water will be backed up to this weir.

The foundations for the Power House are of solid concrete construction, and the superstructure is a combined formation of steel and reinforced concrete. The building is 100 feet wide by 90 feet long. The turbine and generator room is 75 feet by 90 feet, and a two storey lean-to 28 feet wide houses all the high tension and low tension switches. The control switchboard is on a gallery in a lean-to at the end of the building.

The Power House is now being extended 70 feet more for the installation of two new units.

In the Power House are installed at present two 10,000 K.V.A. 3 phase, 60 cycle, 4,400 volt generators built by the Canadian General Electric Company, driven by two 13,000 H.P. Francis type turbines built by the Escher Wyss Company of Zurich, Switzerland. Excitation is provided by two 250 K.W. 125 volt generators, each driven by its own turbine, and each capable of exciting four machines. Governors and oil pumps

Stave Falls Development. Site of second or lower development.

Stave Falls Development — Generator Room showing main units were also provided by the Escher Wyss Company, the pumps being driven by individual wheels of the impulse type.

Six single-phase transformers of 3,000 K.W. capacity each are located on the main floor, each in its own concrete vault with a steel hatch as a top. A travelling crane of 70 tons capacity spans the entire main floor, placing the transformers as well as the generators and wheels directly under the crane. The control switchboard is in a gallery at the east end of the building, giving the operator full view of every piece of moving machinery. All switches are solenoid operated, and, with the fuses, are located in reinforced concrete cells in a concrete lean-to parallel to the main building.

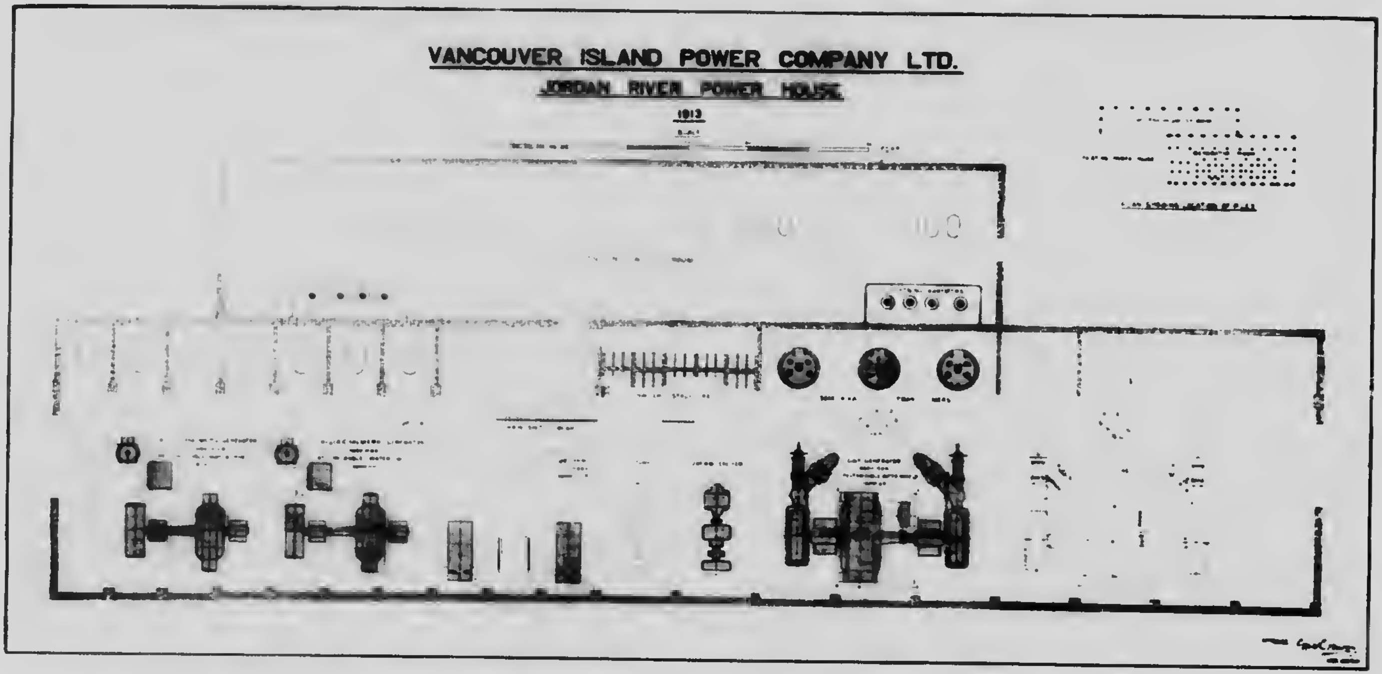
JORDAN RIVER DEVELOPMENT OF THE VANCOUVER ISLAND POWER COMPANY, LIMITED

THE Jordan River Plant of the Vancouver Island Power Company, Limited, a Company subsidiary to the British Columbia Electric Railway Company, Limited, is situated at the mouth of Jordan River, which flows into the Straits of San Juan de Fuca about 40 miles west of the City of Victoria, Vancouver Island.

The Jordan River is a mountain stream flowing in a southerly direction through a deep and precipitous valley. The source of the main river is in Jordan Meadows, which lie about midway between the east and west coasts of the Island, and at an elevation of about 1,700 feet above sea level. Several large creeks join the river in the upper ten miles of its course, the principal streams being Bear Creek, Wye Creek and Alligator Creek. The total drainage area is about 75 square miles, the greater part of which lies at an elevation of over 1,200 feet above sea level, and this entire area is covered by a growth of heavy timber.

The precipitation is heavy, averaging about 90 inches per year over the whole watershed. During the winter months there is a heavy fall of snow varying from 4 to 11 feet in depth in the higher parts. This snow, protected by the heavy timber and underbrush, often remains on the ground until well on in June or July, thus forming a splendid natural reservoir.

This development is of particular interest on account of the high head utilized, the static head at the Power House being 1,145 feet. The Power House is situated on the beach near the mouth of the Jordan River, with the main floor 7 feet 6 inches above high tide level. Water is conveyed to the water wheels in the Power House from a forebay reservoir through steel pipe lines 9,290 feet long. The forebay, which is a small equalizing reservoir formed by two earth fill dams, is about 1,152 feet above sea level, giving a static head of 1,145 feet at the nozzles in the Power House. Water is carried from the diversion point on the Jordan River to the forebay reservoir in a wooden flume about 5½ miles long, built along the east side of the Jordan River Valley. A small dam in Alligator Creek



Vancouver Island Power Company Limited. Jordan River Power House.

diverts the water from that creek into a small flume which joins the main flume about a mile below the main diversion point on Jordan River. Wye Creek joins the river above the diversion dam. Bear Creek flows into the Jordan River about 3½ miles above the main diversion dam, and the Bear Creek storage dam lies near the headwaters of that creek and about a mile above its junction with the Jordan River. The position of the various streams is shown in the key-map.

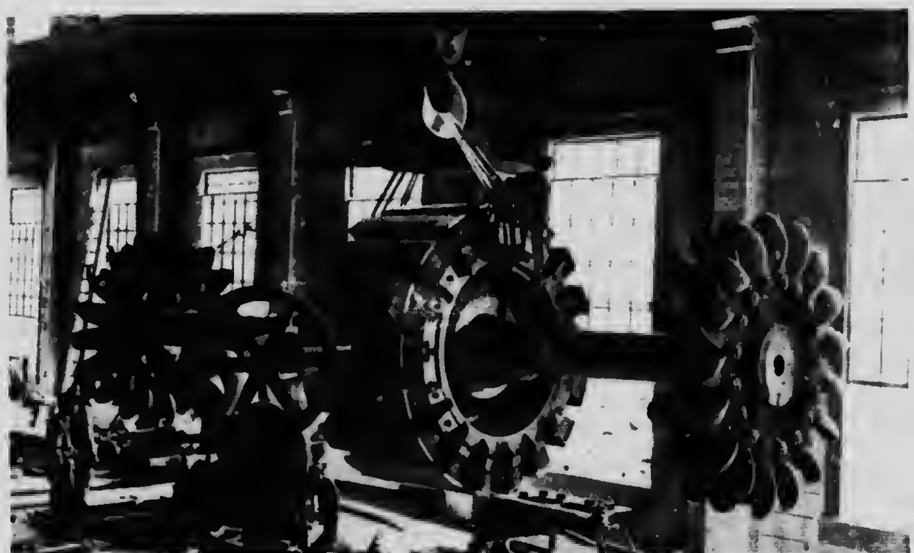
On account of the variable flow of the Jordan River and its tributaries, storage reservoirs form an essential part of the scheme. Five sites suitable for storage dams have been located, but only two of these dams have been constructed at the present time. These dams are known as Bear Creek Dam and Jordan River Dam.

BEAR CREEK DAM

Bear Creek Dam is situated on Bear Creek about a mile above the junction of that stream with the Jordan River. The dam is an earth embankment built by the hydraulic process. The greatest height above the bottom of the foundation is 57 feet and the length on the crest is 1,020 feet. The crest has a width of 15 feet; the downstream slope is 2½ to 1 and the upstream slope 3 to 1. The spillway is excavated from the solid bedrock at the north end of the dam. The volume of material in the dam, as measured in the embankment, is 148,000 cubic yards.

Vancouver Island Power Company Limited.
Front view of Power House showing completed building and tailraces.

Vancouver Island Power Company Limited.
Looking East, showing front of Jordan River Power House.



Vancouver Island Power Company Limited.
Assembled rotating parts. No. 3 unit, weight about 64 tons.

In order to ensure watertightness and provide a secure foundation, not only for the initial structure 57 feet high, but for an ultimate structure 87 feet high for developing the reservoir to its full capacity, steel sheet-piling was driven to bedrock, thus forming a curtain wall across the valley.

This dam forms a lake 285 acres in extent and provides storage available for power purposes amounting to 328,000,000 cubic feet. The area of Bear Creek watershed above the dam is 8 square miles, and is at an elevation exceeding 2,000 feet above sea level.

Vancouver Island Power Company Limited.
No. 3 unit in position showing governors, oil pumps and gate valves.

The construction of the dam was started in November, 1910, and the work was completed in April, 1912. Since that time the dam has been in service and its behaviour has been entirely satisfactory. There has been practically no settlement of the fill.

JORDAN RIVER DAM

Immediately below the junction of Wye Creek and Jordan River the canyon narrows and is crossed by a ridge of bedrock which extends well up on both sides of the canyon. This site was recognized as the best for a dam of a permanent character. It was originally intended to place the diversion dam at this point, but owing to the limited time, the lack of a ready supply of material for concrete near the site, and also in view of the probability of using the site at some future time for the construction of a high dam which would, in addition to diverting the stream into the flume, form a large reservoir, another location was

[illegible] Company Limited. Interior view of Jordan River Power House before extension, showing switchboard and units Nos. 1 and 2

Vancouver Island Power Company Limited.
No. 3 Pipe Line as seen from Power House.

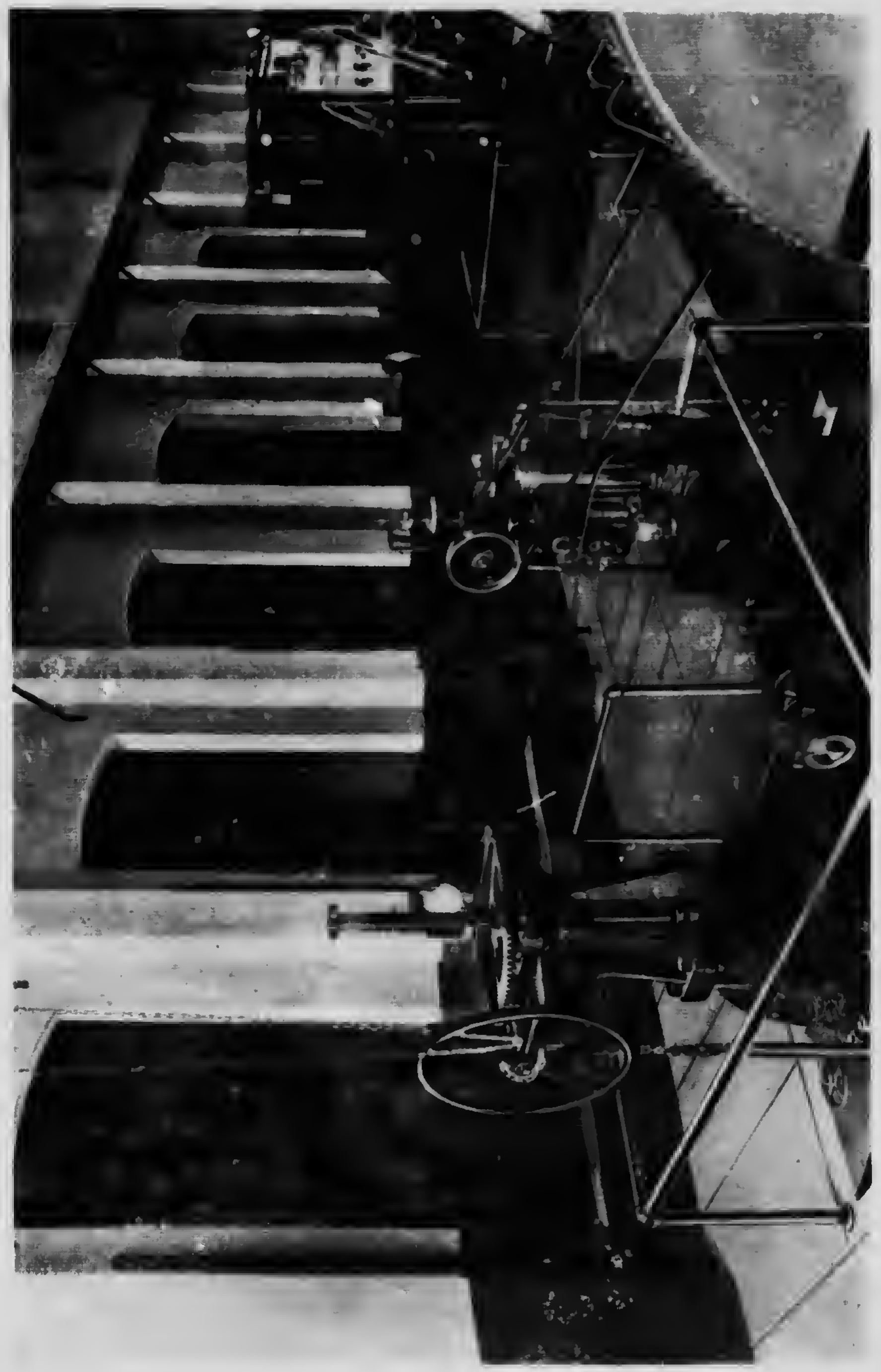
chosen for the temporary diversion dam about 2,000 feet further up stream. In order to utilize the runoff from Wye Creek, a small diversion dam was also built on this creek and a branch flume was built to carry the water from Wye Creek Dam to the main flume on the east bank of the Jordan River.

The temporary Jordan River diversion dam was a substantially built rock-filled crib structure sheeted with two thicknesses of 2 inch planks. It was founded on bedrock and the bottom edge of the upstream sheeting was set in a concrete sill. The length on the crest was 128 feet and the width 8 feet. Both faces were built on 1 to 1 slopes and the maximum height was 18 feet above bedrock. The flume intake was located at the east end of the dam and was also constructed as a rock-filled crib and lined with two layers of 2 inch planks. The regulation of the flow of water was controlled by three timber headgates operated by rack and pinion. These gates discharge directly into an intake basin depressed 2 feet below the floor of the flume and provided with sand gates through which the silt and sand which might collect in the basin could be discharged.

The Wye Creek Dam was of similar construction, but the crest length was only 90 feet.

These two temporary dams were completed during the summer of 1911 and gave satisfactory service until they were replaced by a permanent structure built on the site which had originally been chosen for the diverting dam.

The storage provided by the Bear Creek reservoir was sufficient to supply the demands of the first two units installed in the Power House, but on account of the rapidly increasing demand for power the construction of a high storage dam on the Jordan River was commenced in August, 1912.



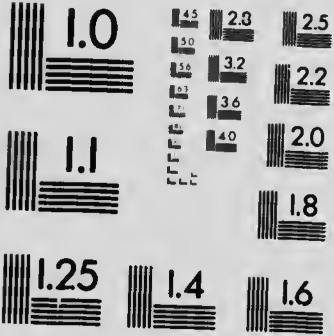
The Jordan River Dam is a hollow reinforced concrete structure of the Ambursen type, with crest 1,268 feet above sea level. The dam is 891 feet in length along the crest. A spillway is provided near the east end of the dam with curved crest and rollway apron which enables water overflowing the spillway to fall clear of the toe of the buttresses; the spillway is 305 feet long with the crest 8 feet below the top of the dam and provides for a discharge of 23,000 cubic feet per second. The extreme height of the dam is 126 feet above the lowest point of the foundation on the centre line. This dam is believed to be the highest dam in Canada, and it is the second highest dam of the Ambursen type so far constructed.

Vancouver Island Power Company Limited. Flume and Railroad on trestle.

The Jordan River Dam consists of a reinforced concrete face or deck inclined at an angle of 45 degrees and supported on concrete buttresses spaced 18 feet centre to centre. These buttresses are 12 inches thick at the top and increase, by steps or lifts 12 feet high, to a thickness of 42 inches at the bottom of the highest buttress. The upstream edge is built on a slope of 1 to 1; the downstream edge has a batter of 1 to 4 from the base to a point 18 feet below the crest, above which point it is vertical. At the upstream edge a heavy reinforced haunch or shoulder is built on either side of the buttresses and the decks are supported on these haunches. The buttresses project beyond the haunches a distance equal to the thickness of the deck, and a bonding groove or key is cast in this projection. No vertical reinforcement is used in the buttresses excepting along the downstream edge and in the haunches, where heavy reinforcement is provided to carry the decks; horizontal reinforcement is used along the top and bottom of each of the 12-foot lifts or steps.

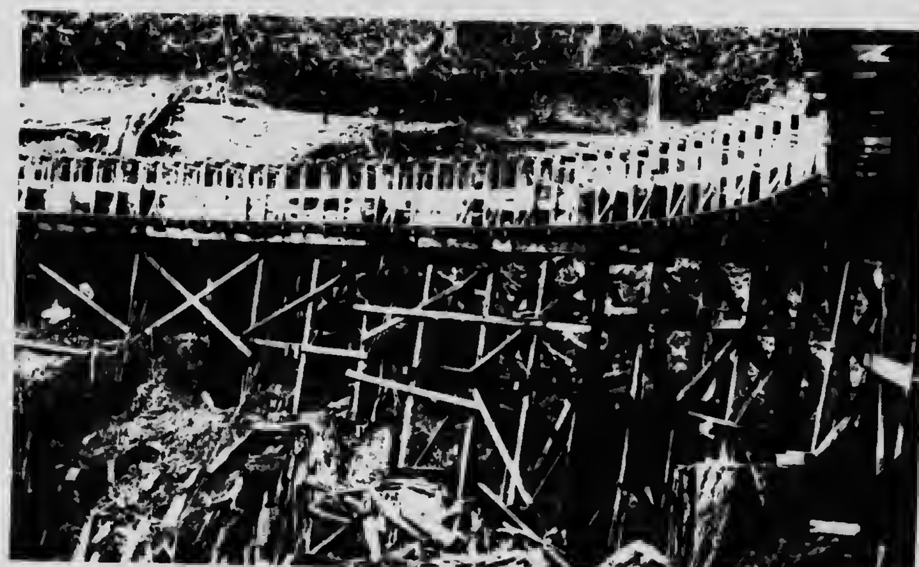
MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



APPLIED IMAGE Inc
1653 East Main Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phone
(716) 288 - 5989 - Fax

Vancouver Island Power Company Limited. Flume between Jordan River Dam and Forebay Reservoir.



Vancouver Island Power Company Limited. Main Flume, showing intermediate bents being erected.

Vancouver Island Power Company Limited
Flume and Railroad above Forebay.

Horizontal tie beams, which are reinforced top and bottom, run between the buttresses at various elevations and give them lateral support; the reinforcement in these beams is continuous through each three consecutive buttresses but is not carried continuously through the dam on account of possible strains set up by expansion and contraction.

Only two sizes of reinforcing steel were used in the entire dam, these being 7/8 inch and 5/8 inch square corrugated bars; 7/8 inch bars were specified for all of the main reinforcement, and 5/8 inch bars for vertical reinforcement. The total weight of steel used in the dam was 380 tons.

Practically all the material in the dam was handled by a cableway spanning the valley on the centre line of the dam; the length of the span was 920 feet.

Construction work was carried on right through the winter, all work being confined to those parts of the dam on both sides of the river above high water level. This was done under great difficulties, as the winter was particularly severe; during part of the time the ground was covered with 6 feet of snow, some of which remained on the ground until well on in May. The cost of clearing away the snow was a considerable item, and occupied much time.

The main flume follows the east side of the Jordan River Valley from the Jordan River Dam to the forebay reservoir, a distance of about 5½ miles. The side of the valley is steep for the entire distance, and precipitous in places.

Vancouver Island Power Company Limited. Bridge carrying flume from Y Creek at junction with main flume prior to construction of Jordan River Storage Dam.

Vancouver Island Power Company Limited. Upstream face of Jordan River Dam. The old flume from the original Diversion Dam is seen on the left.

The flume is built entirely of timber, and was designed for an ultimate carrying capacity of 175 cubic feet per second. The box is 6 feet by 6 feet in section, allowing for a depth of 5 feet 6 inches of water, and has a grade of 1 foot in 1,000 feet. As originally built the sides were only boarded up to a depth sufficient to carry 75 cubic feet per second and the bents were placed 15 feet centre to centre In order to support the additional weight of water, it was necessary to erect intermediate trestle bents, making the bents 7 feet 6 inches centre to centre; during the summer of 1913, the necessary additions to the flume were made to complete it to its ultimate carrying capacity.

Vancouver Island Power Company Limited. Jordan River Dam, with the old flume on the right of the picture, fed by a temporary flume placed parallel to the Dam.

The railroad which runs parallel to the flume for its entire length, greatly facilitated the work, as all lumber and other construction materials were delivered at the points at which they were to be used.

Five gates are provided along the length of the flume. These are set in short boxes formed by dropping the floor of the flume about 3 feet below grade, and serve to catch all sand and silt which enters the flume. The gates may also be used to empty the flume quickly in case of emergency.

The flume discharges into the forebay reservoir, which is a small artificial lake of 4,350,000 cubic feet capacity, formed in the flat between two hills by two earth fill dams across the valleys immediately to the north and south of the ridges. These dams, or embankments, were built of the material excavated from the higher ground lying between them, thus adding to the capacity of the reservoir.

The north dam has a length of 560 feet on the crest and contains 24,290 cubic yards of material. The south dam is 700 feet long and has a volume of 26,560 cubic yards. The slopes of both embankments are 2½ to 1 on the water side and 2 to 1 on the outer side. The maximum height of both dams is 35 feet.

A spillway, with crest 5 feet below the top of the dams, is built in solid ground near the east end of the north dam.

Two riveted steel pipes pass through the south dam; the inner ends of these intake pipes are fitted with 54 inch diameter hand operated roller bearing sluice gates, and protected with trash racks. To the outer ends of these intake pipes the pipe lines which convey water to the Power House are connected; one of these outlets provides water for Units Nos. 1 and 2, and the second opening serves No. 3 Unit.

The pipe line connected to the first outlet is 44 inches in diameter, and 3,010 feet long. It is of riveted steel construction and varies in thickness from ¼ inch to 5-16 inch. At its lower end, a Y pipe is provided. To the west branch of this Y, No. 1 pipe line is connected; this pipe line is of lap welded construction, 36 inches in diameter at the upper end and tapering to 30 inches at the Power House, and is 6,280 feet long. The upper end of the pipe line serving No. 2 Unit is connected to the east branch of the Y; No. 2 pipe line is of riveted construction, and varies in diameter from 36 inches at the top to 30 inches at the Power House, the thickness ranging from ½ inch to 1 inch at the lower end. Both pipe lines are controlled by gate valves placed just below the Y pipe. The pipe line for

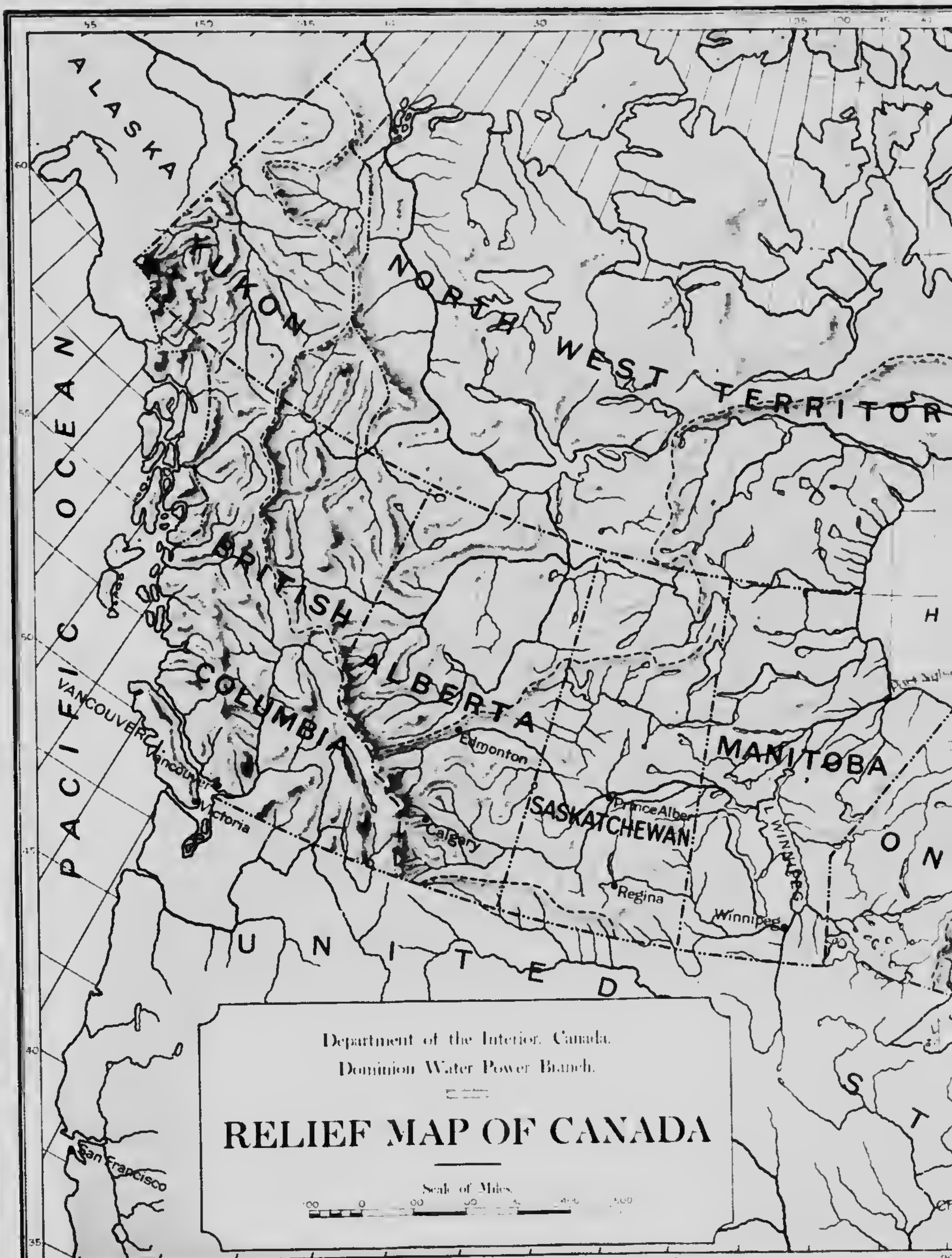
Vancouver Island Power Company Limited. Upstream showing portion of Jordan River Dam in river bed, in course of construction.

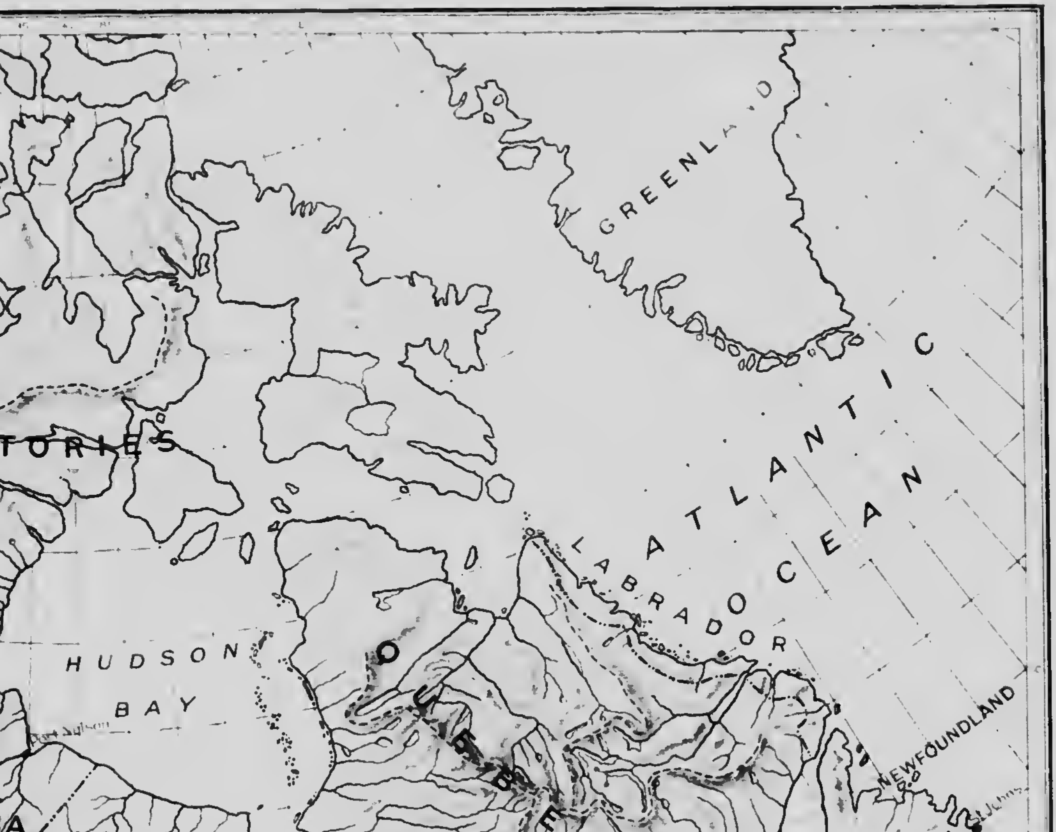
yards of
s. The
ter side.

near the

e intake
rotected
ey water
s Nos. 1

eet long.
ach. At
pipe line
he upper
pper end
pipe line
nches at
l. Both
line for


Department of the Interior, Canada.
Dominion Water Power Branch.
RELIEF MAP OF CANADA
Scale of Miles
ALASKA
YUKON
NORTH WEST TERRITOR
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
PACIFIC OCEAN
VANCOUVER
Vancouver
Victoria
Edmonton
Calgary
Prince Albert
Regina
Winnipeg
L. WINNIPEG
San Francisco
UNITED
S T
O N
H



GREENLAND
ATLANTIC
OCEAN
LABRADOR
HUDSON
BAY
QUEBEC
ONTARIO
NEWFOUNDLAND
GULF OF ST LAWRENCE
NEW BRUNSWICK
NOVA SCOTIA
Quebec
Montreal
Toronto
Niagara
New York
Chicago
Halifax
St John
L. MICHIGAN
L. ERIE

Vancouver Island Power Company Limited. West end of Jordan River Dam, showing buttresses and tie beams.

No. 3 Unit is connected to the second intake pipe in the south dam at the forebay reservoir. This pipe line has a total length of 9,290 feet and is located parallel to pipe lines No. 1 and 2. For a distance of 2,508 feet below the intake, No. 3 pipe line is of riveted steel construction 54 inches in diameter at the top and tapering to 48 inches in diameter at the lower end where it connects with a lap welded pipe ½ inch thick and 48 inches in diameter; this diameter is maintained except for a length of 130 feet at the back of the Power House, where the diameter is reduced to 44 inches; the thickness at the Power House is 1⅛ inches. The pipe lines are liberally provided with manholes, and air valves are placed on the pipes at frequent intervals.

In excavating the pipe trenches, all surface soil was removed and the pipes rest on a firm foundation of rock, hardpan or gravel, throughout their length. Drainage is provided for by packing small rocks and gravel around the bottom of the pipes, and numerous concrete deflecting walls built at intervals across the pipe trenches turn seepage water into natural drains along the hillside

JORDAN RIVER POWER HOUSE

The original Power House building completed in 1911 was a concrete structure 91 feet 6 inches long and 47 feet wide, in which two units of 4,000 K.W. capacity were installed with the necessary exciters, low and high tension switches and transformers.

On account of the rapidly increasing load on the Company's system, the original installation has been added to. The additions necessitated the extension of the Power House

Vancouver Island Power Company Limited. Jordan River Dam. Crib work for protection of new flume below Dam.

Vancouver Island Power Company Limited. Jordan River Dam showing spillway.

building to accommodate a new 8,000 K.W. unit with space for a fourth unit, and an entirely new high tension switchroom for the completed plant behind the Power House. The extensions were completed in October, 1914.

The completed Power House is a reinforced concrete building founded on concrete piles 12 inches in diameter, which penetrate to bedrock lying at a depth of 45 feet to 75 feet below the surface. The floor of the older portion of the building is 7 feet 6 inches above high tide level; the floor of the new portion is placed at an elevation 5 feet higher. The completed generator room is 211 feet 6 inches long and 47 feet wide, in which are installed

Vancouver Island Power Company Limited. Buttresses, Jordan River Dam.

two identical 4,000 K.V.A. units made up of Allis-Chalmers-Bullock 3 p[illegible], 60 cycle, 2,200 volt generators driven direct at a speed of 600 revolutions per minute [illegible] a single Doble water-wheel of 6,000 H.P. mounted on one end of the shaft, and overhanging the bearing at that end of the unit. The shaft is a nickel steel forging 14 inches in diameter and supported in two bearings 40 inches long.

Water is conveyed from the terminal end of each pipe line through a cast steel flanged taper pipe which is bolted to the flanged end of the pipe line. This taper piece decreases in diameter from 30 inches to 24 inches at the outlet end, where it is bolted to a hand operated, 24-inch single disc, steel body, rising stem gate valve which is provided with a by-pass. The steel nozzle casting is bolted to this valve. The jet of water is projected on to the wheel through a Doble needle regulating nozzle and the governing is done by a type Q Lombard governor, operating the needle gear by means of an oil pressure

Vancouver Island Power Company Limited. East end of Jordan River Dam showing spillway.

cylinder. Surges or rams in the pipe line caused by the quick closing of the main nozzle are minimised by the Doble auxiliary relief nozzle. This nozzle is similar to the main nozzle, but is placed below it and the stream is discharged freely down the tailrace. This relief nozzle is operated by the governor through links connected to a dashpot on the relief needle stem. The gradual closing of the main nozzle does not operate the relief, but in case of quick closing the relief nozzle opens. Heavy coil springs bring about the gradual closing of the relief nozzle, and the time of closing can be regulated by adjusting the dashpot by-pass valves. Oil pressure for the operation of the governor is supplied by a motor-driven oil pump which automatically maintains the pressure in the supply tank.

No. 3 Unit is made up of one 8,000 K.V.A. Canadian General Electric 3 phase, 60 cycle, 2,200 volt generator, driven by two Pelton-Doble water wheels, one mounted on each end of the shaft and overhanging the bearings. The water wheels are rated at 13,000 H.P. The shaft is a hollow nickel steel forging 16 inches in diameter in the bearings, which are 60 inches long; these bearings are of the single shell type similar to those on No. 1 and No. 2 Units.

The two wheels on this unit are supplied with water through a flanged cast steel Y pipe which is bolted to the terminal end of the pressure pipe line immediately behind the unit foundation. The entrance connection of the Y is 44 inches in diameter and the branches are 34 inches. To these branches are bolted cast steel taper pipes, reducing to 24 inches, and to these are bolted 24 inch single disc steel body gate valves. These gate valves are operated by small reversible water wheels mounted on brackets on the yokes of the valves; the water motors operate a bronze nut on the rising stem of the valve through a system of spur and bevel gearing. Water is supplied to the wheels through short pipes connected to the hood of the valves, and an automatic device is provided which prevents over-running. The cast-steel nozzle bodies of the main and relief nozzles are bolted directly to the gate valves.

Each wheel is provided with an entirely separate direct motion oil operated, relay type Pelton-Doble governor; the piston of the governor motor cylinder is mounted directly on the extended needle stem of the main nozzle, and from this stem the auxiliary or relief nozzle is operated by double levers connected to the dashpot on the stem of the auxiliary needle. This direct application of the motive power of the governor to the needle stems of the water wheel, without any intermediate connections, is a great improvement over the old system of applying the power through a system of links, with their inherent lost motion and back-lash. These governors have given exceptionally good regulation without causing any appreciable surges in the long pipe line.

Oil pressure for the operation of the two governors is provided by a water motor driven gear type pump with a welded steel oil pressure accumulator tank. The pump motor is controlled by a float in a chamber connected with the accumulator tank. The governors may also be controlled by hand.

Three exciter units are provided. Two of these consist of one 100 K.W. 125 volt D.C. generator, with a 150 H.P. water wheel at the other end. The third exciter set consists of a 200 K.W. 125 volt D.C. generator on the shaft of which are mounted a 300 H.P. induction motor and a 200 H.P. water wheel. Water is supplied to the exciter water

Vancouver Island Power Company Limited. Jordan River Dam with water passing over spillway.

Vancouver Island Power Company Limited. Downstream face, Jordan River Dam.

Vancouver Island Power Company Limited. Bear Creek Storage Dam looking East. December 9th, 1912.

wheels from a header connected to all three pipe lines, and an arrangement of valves permits any exciter unit to be run with water from any pipe line.

The low tension generator and transformer switches are placed on the main floor at the west end of the new portion of the building; these switches are of the H-6 type of the Canadian General Electric Company. The bus bars are carried in concrete cells in the basement, immediately under the low tension switches.

The transformer equipment consists of two banks of three single phase 1,450 K.V.A. transformers, with one spare transformer, and one bank of three 3,000 K.V.A. single phase transformers, stepping up the voltage from 2,200 to 60,000 volts.

These transformers are all of the oil insulated water cooled type and were supplied by the Canadian Westinghouse Company; they are placed in open compartments behind the units on the generator floor.

Current at 60,000 volts is conducted from the transformers through the back wall of the generator room in porcelain wall bushings into the high tension switch room. The high tension buses are supported on insulators on the back wall of the room; and the 60,000 volt type G.A. Westinghouse switches are in a line down the centre of the room, directly under the disconnecting switches, which are mounted on a structural steel frame. All high tension conductors are of 1 inch copper tubing. Two 60,000 volt lines leave the building through large wall bushings, and lead to a steel distributing tower a short distance in the rear of the Power House.

The transmission line from Jordan River Power House to Victoria Substation is about 37 miles long. For about 15 miles the location follows the shore, then strikes inland to Victoria. The poles are of cedar cut along the line; they vary in height from 50 to 60 feet, and have a minimum diameter at the top of 9 inches. The conductor is aluminum cable made up of seven strands of No. 8 wire; two piece 60,000 volt suspension insulators are used throughout the length of the line. Cross arms for two circuits are provided, but only one circuit has been installed; the second circuit will be strung in the near future.

LINK RIVER DEVELOPMENT OF THE OCEAN FALLS COMPANY, LIMITED

THE property of the Ocean Falls Company, Limited, is situated at Cousins Inlet, about 300 miles north of the City of Vancouver, and the situation of the Company's Plant is particularly favorable for docking large ocean steamers, as well as for smaller boats. For providing cheap power for the operation of its pulp and paper manufacturing plant the Company has developed the Link River project. The total capacity of the turbines at present installed amounts to 11,200 H.P., but provision has been made at the headworks for doubling this capacity at a later date.

A small storage dam is provided at the lower end of Link Lake, and at a point about 800 feet from the Power House a concrete diversion dam has been installed on the Link

Ocean Falls Company Limited. "Ocean Falls."

Ocean Falls Company Limited. Looking Northwards on Link Lake.

Ocean Falls Company Limited. Pulp and Paper Manufacturing Plant.

River. This dam is provided with an intake section with two 12 foot diameter openings for pipe line connections controlled by sluice gates. The dam is of gravity section, with a maximum height of 60 feet above the lowest point of the foundation.

From the dam, the water is conveyed to the Power House through one steel pipe line 12 feet in diameter, 776 feet long. The lower end of the pipe line is parallel to the back wall of the Power House; a branch pipe coming off the main pipe line is provided for each water wheel unit. Provision for a duplicate pipe line between the dam and the Power House is provided for.

Three hydro-electric units are at present installed; these consist of 600 K.W., 3 phase, 60 cycle, 440 volt Westinghouse generators, each driven direct by a turbine of 900 H.P. supplied by James Gordon & Company, operating under a head of 115 feet. A 50 K.W. motor-generator set supplies power for the electrically driven mono-rail system used on the wharves for loading lumber, etc.

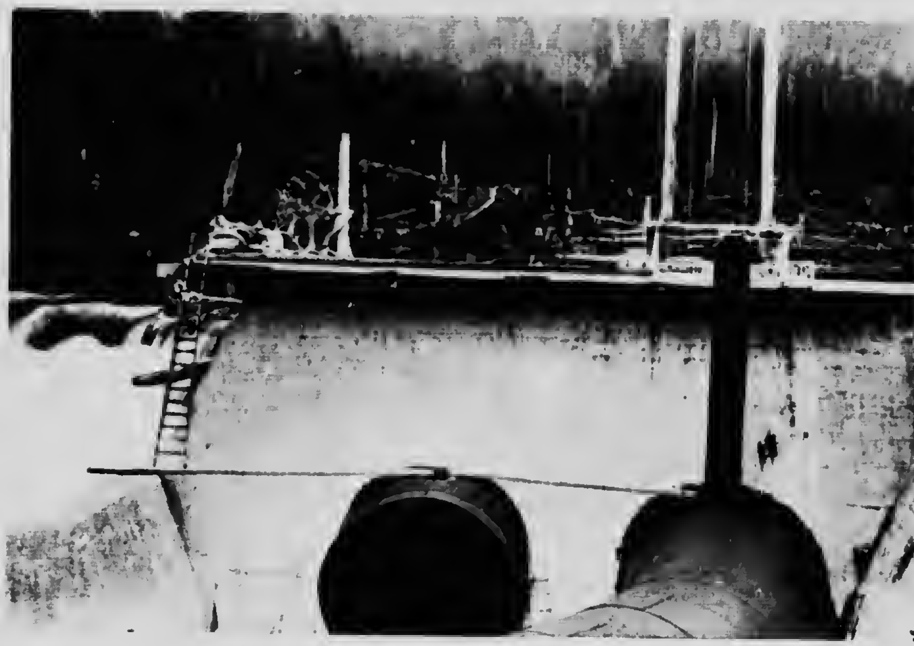
The units are controlled by an 8 panel Westinghouse switchboard.

Ocean Falls Company Limited. Looking upstream towards diversion dam.

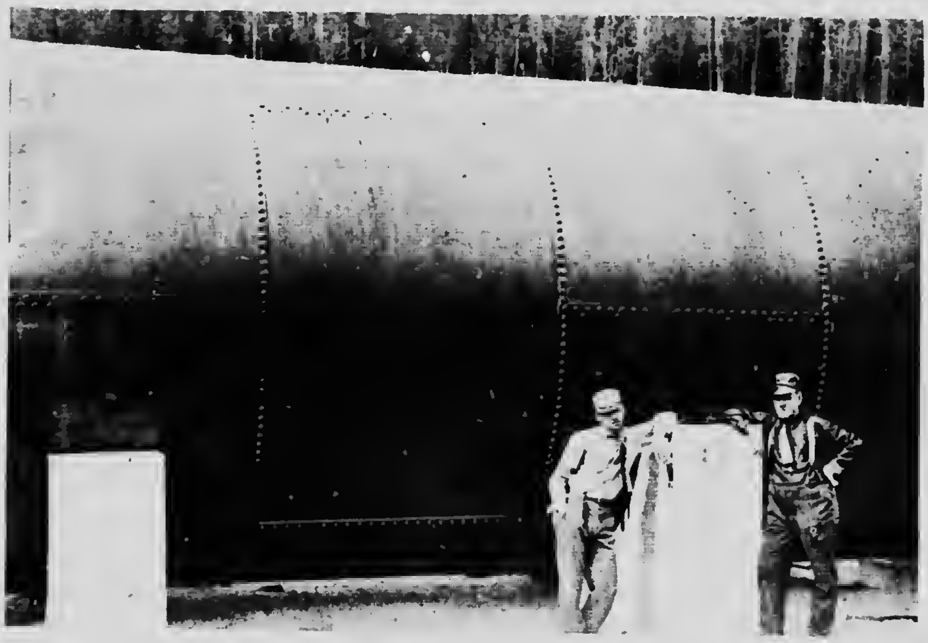
Ocean Falls Company Limited. The Camp at Ocean Falls.

Ocean Falls Company Limited. Pipe line 12 feet in diameter and Ocean Falls.

Ocean Falls Company Limited. Pipe line and Link River near Power House.



Ocean Falls Company Limited. Diversion dam and pipe line intake.



Ocean Falls Company Limited. Pipe line, 12 feet in diameter.

Ocean Falls Company Limited   Pipe line at back of Power House.

Ocean Falls Company Limited. Interior view of Power House showing Hydro-Electric Units.

For the operation of the pulp grinders, hydraulic turbines are provided; the grinders are in groups of four, each group being driven by a 1,600 H.P. turbine of the Francis type, supplied by Jens Orten-Boving.

PUNTLEDGE RIVER WATER POWER DEVELOPMENT OF THE CANADIAN COLLIERIES (DUNSMUIR) LIMITED VANCOUVER ISLAND

THE Puntledge River, which is the natural outlet of a lake of the same name, discharges into the Gulf of Georgia on the eastern side of Vancouver Island, British Columbia, at a point about 60 miles north of the City of Victoria. The Canadian Collieries (Dunsmuir) Limited, which owns and operates a group of coal mines at Union Bay, has developed the power possibilities of this stream, and the separate steam plants which were formerly in operation at each of the Company's mines have been superceded by a central hydro-electric power plant with 13,200 volt distribution system, whereby considerable economies in operation have been effected.

The maximum recorded flow of the Puntledge River is 3,500 cubic feet per second, and the minimum is 330 cubic feet per second. A study of the flow curves available showed

Canadian Collieries (Dunsmuir) Ltd. Power House during construction.

that by creating sufficient storage in Puntledge Lake, a constant flow of 800 cubic feet per second could be maintained.

STORAGE DAM

An impounding dam was built at the outlet of the lake and a channel 5 feet in depth was cut in the bottom of the outlet, making it possible to draw the water off below the original level. The dam raises the water 23 feet above the original lake level and provides useful storage of 132,000 acre-feet.

The over-all length of the dam is approximately 300 feet with a crest elevation of 445 feet above sea level; the gate sill is at Elevation 416. In general type the dam is a buttressed concrete wall having a spillway 100 feet long; the combined capacity of the spillway and outlet gates is 10,000 cubic feet per second, which is well in excess of any recorded flood. The storage of water and its flow over the spillway is controlled by wooden needles which are so designed and arranged that they may be readily removed in time of flood. Six outlet gates are provided, each 5 feet by 6 feet; the gates are of the butterfly type with vertical axes, and are controlled by gears on the operating platform at the crest of the dam. Government regulations required that a log sluice be provided, and this was secured by omitting the wall in one dam panel and substituting suitable stop-logs which are readily removable one at a time to obtain the necessary depth for the passage of logs at any stage of the water.

The dam is built on solid bed-rock. Precautions were taken to insure against any uplift pressure by drilling numerous holes in the rock under the base of the dam and fitting

Canadian Collieries (Dunsmuir) Ltd. View showing downstream face of Storage Dam.

Canadian Collieries (Dunsmuir) Ltd. Storage Dam.

Canadian Collieries (Dunsmuir) Ltd. Diversion Dam.

them with open pipes leading to the lower face of the dam. The concrete used in the dam was mixed in the proportion 1 : 2½ : 5, with approximately 10 per cent. of hydrated lime to obtain watertightness.

DIVERSION DAM

From the outlets in the storage dam the water flows in the natural bed of the river to the diversion dam about 2½ miles below the lake. The diversion dam is a partially reinforced concrete structure of the overflow or spillway type with a concrete intake and gate chamber at one end of the spillway section, which is 100 feet long. Two gates 6 feet high and 7 feet wide are provided in the intake; the gates are made up of steel plates riveted to channel iron frames and are mounted on rollers to minimise friction. Watertightness is secured by the use of flexible diaphragm strips which bear on the sides and top of the gateway, and a cushion which seats into an inverted channel set in the floor below the gate. The gates are provided with rising screw-stems and are operated by means of bevel-geared operating stands placed on the working platform at the dam crest. The gate openings are protected by steel screens which are easily handled to allow for repairs or cleaning.

CANAL AND FLUME

At the diversion dam the water enters a system of canals and flumes 3,400 feet long, in which length there are many sharp curves necessitated by the broken nature of the country. The canal sections occur in solid rock, sand, gravel and clay, and with the exception of some portions in impervious clay, all are lined with concrete. The sections of the canal are connected by wooden flumes which have the same carrying capacity as the canal.

Canadian Collieries (Dunsmuir) Ltd. Flume Intake at Diversion Dam.

The flumes are approximately semi-circular in section, built up of staves laid on steel suspension rods supported by side girders laid on trestle bents placed 16 feet apart. The flume is 12 feet deep and 7 feet wide; the staves are dressed to $2\frac{9}{16}$ inches by $5\frac{7}{16}$ inches, and the suspension rods are $\frac{3}{4}$ inch in diameter placed 24 inches apart. Each side girder is built up of two 8 inch by 16 inch fir timbers resting on the 12 inch by 12 inch cap of each trestle bent. The trestle bents are securely braced to insure stiffness and are founded on concrete footings.

The canal and flume line terminates in a short section of reinforced concrete flume, the section of which changes gradually to secure a smooth entrance into the pipe line intake.

Canadian Collieries (Dunsmuir) Ltd. General view of Flume.

A spillway of sufficient capacity to carry away the entire flow in the flume is provided in one side of the reinforced concrete flume close to the pipe line intake structure.

At the canal entrance to the pipe line intake, a rotary balanced steel gate of the "Taintor" type is installed. This gate is 12 feet wide and 10 feet high, and is made up of steel channel frame covered with steel plates; it is balanced by means of a heavy cast iron beam attached to the channel arms which extend back into the intake beyond the trunnions. Water-tightness is secured by means of flexible diaphragm strips fastened to the edge of the gate, and which slide in grooves in the walls of the gateway. The gate is manually operated by means of pinions engaging with segmental racks on the face of the gate, the pinion shaft being geared to an operating stand on the working platform at one side of the gateway.

PIPE LINE INTAKE STRUCTURE

The pipe line intake is a vertical cylindrical chamber of reinforced concrete about 25 feet in diameter and having a height above the bottom of the outlet opening of about 30 feet. The canal or flume entrance is on one side near the top, and the pipe intake is directly opposite and at the bottom of the chamber. Between the intake and the outlet openings the chamber is divided into two sections by a weir wall and screens. The intake section forms a sedimentation basin and can be drained through a sluice gate blow off. The concrete in the intake structure is composed of the same aggregates as used in the dams, including 10 per cent. of hydrated lime.

The outlet opening is funnel shaped, decreasing from 12 feet in diameter at the inner end to 8 feet in diameter at the outer end in a length of 7 feet. For connection to the 96 inch wood stave pipe, a cast iron caulking ring is set in the concrete. This ring forms a rabbet for the staves of the pipe with taper clearances for caulking at the end and also all around the outside of the pipe. Oakum and lead wool are used for caulking.

The elevation of the pipe line intake is 414 feet above sea level, giving a static head of 350 feet at the Power House.

PIPE LINES

From the pipe line intake the water is carried in a wood stave pipe 8 feet in diameter and 4,500 feet long, to a "Y" structure with two outlets for 72 inch diameter pipes. Each of these outlets is fitted with a 72 inch diameter gate valve. The next section of the system

Canadian Collieries (Dunsmuir) Ltd. Tainter Gate at Forebay.

consists of one line of 72 inch diameter wood stave pipe which is to be duplicated at some future time, the present development being only one half of the ultimate development. This 72 inch pipe is 4,500 feet long and terminates in a junction structure having inlets for two 72 inch pipes and outlets for four pipes 50 inches in diameter; 72 inch gate valves are provided to control the 72 inch openings, and 50 inch gate valves are provided on the 50 inch openings with which the pipe lines 50 inches in diameter conveying water to the Power House connect. Only two of these pipes are installed at the present time; they are built of wood staves for a distance of 3,170 feet and for the remaining distance of 660 feet to the Power House the pipes are of steel.

Canadian Collieries (Dunsmuir) Ltd. Forebay, showing Screens and Tainter Gate in open position.

The staves in the 96 inch pipe are $3\frac{9}{16}$ inches thick and $5\frac{9}{16}$ inches wide, 58 staves being used in the circumference. The staves for the 72 inch and the 50 inch pipes have a thickness of $2\frac{9}{16}$ inches and $2\frac{1}{2}$ inches respectively, and widths of $5\frac{5}{8}$ inches and $5\frac{9}{16}$ inches. There are 43 staves in the circumference of the 72 inch pipe, and 31 staves in the 50 inch pipe. All staves are manufactured from selected clear Douglas fir. The bands for all pipes are uniformly 1 inch diameter. The maximum spacing is 12 inches centre to centre, and the minimum spacing 2 inches, which is as close as the band shoes can be laid. Where the pressure required closer spacing than this, the size of the pipe was decreased and this factor determined the lengths of the sections.

The bands are made up in two sections, one having threaded ends and the other button head ends. Each band has two coupling shoes of malleable iron; these coupling shoes are of special design and were adopted only after experiments had been made on shoes of various patterns.

Manholes are fitted to the stave pipes at frequent intervals; at the summits they are also provided with automatic air valves to permit the free exit or entrance of air when the pipe is being filled or emptied. The manholes and air valves are held in place by bands which are attached to, or pass over the saddles.

The stave pipes are laid in a shallow trench for practically their entire length, but in one depression for a distance of 820 feet the pipe is supported on concrete piers.

Where the minimum spacing of the bands is reached on the 50 inch wood stave pipes, the construction is changed to steel pipes of the lock bar type. The thickness of the steel pipe increases from $\frac{3}{8}$ inch at the upper end to $\frac{9}{16}$ inch at the Power House. These pipes are securely anchored at both ends and at about the middle of their length there are expansion joints made of steel castings with packed slip joints. The lower ends of the pipes in the Power House are provided with closing pieces connecting them to the hydraulic shut-off valves installed at the turbines.

The junction structures connecting the 96 inch and the 72 inch pipes, and the 72 inch and the 50 inch pipes are built up of heavily reinforced concrete. These connections are unusual for use under such high pressures, the usual method of accomplishing such connections being by means of cast steel or riveted steel plate "Y" pipes.

The junction between the 96 inch and 72 inch pipes was designed to withstand a maximum pressure of 115 lbs. per square inch, and that between the 72 inch and 50 inch

Canadian Collieries (Dunsmuir) Ltd. 8 Foot Wood Stave Pipe Line.

pipes for 160 lbs. per square inch. The 96 inch pipe is connected to the first "Y" structure by means of a cast iron ring set in the concrete, forming a bell end which receives the wood stave pipe and allows for caulking. All other pipe connections with these concrete structures are made with cast iron flanged sleeves set in the concrete to which the gate valves are attached. The gate valves are set in concrete cast in one piece with the junction structures, thus making very rigid construction. The generous use of gate valves enables the isolation of any one of the connecting pipes and the operation of the plant through either of the 72 inch pipes, and any or all of the 50 inch pipes.

Canadian Collieries (Dunsmuir) Ltd. Wood Stave Pipe near Power House. End view.

Watertightness of the concrete "Y" structures was obtained by the use of rich mixtures, using fine aggregates in the proportion 1 : 1 : 2, the gravel varying from pea size up to 1 inch. The inner surfaces, for a thickness of 2 to 3 inches, were made with Portland Cement mortar mixed 1 part cement with 1½ parts sand. The inner surface was finally covered with several coats of asphaltum applied hot.

POWER HOUSE

The Power House is a reinforced concrete structure, built on a rocky site on the river bank. The present building provides space for two generating units and covers an area of 34 feet by 117 feet, which is approximately half the area of the building contemplated for the ultimate development. Provision has been made in the design for the extension of the main body of the building to house the remaining units without interfering with the operation of the present plant. The building has been designed with concrete crane girders on which a 40 ton crane operates. The concrete roof is supported on steel trusses 20 feet apart with 9 inch "I" beam purlins.

The annex section of the Power House has been built complete, and space is provided to accommodate all the switching and auxiliary electrical apparatus for the completed plant. This section of the building is three storeys high and has a ground area of 18½ feet by 65½ feet. It is built of reinforced concrete with concrete floors and roof.

TURBINES

There are installed in the Power House two Escher-Wyss turbines of the reaction type with multiple balanced gates operated by governor. Each unit is provided with a hydraulically operated gate valve in conjunction with the turbine. Under the available head of 350 feet (static) each turbine is rated at 4,700 H.P. at 500 revolutions per minute.

On account of the great length of the pipe line and the high velocity of water in the pipe, the matter of regulation presented some interesting problems. Dangerous surges and rams would be set up in the pipe by quick action of the turbine governors, and in order to avoid this danger, a relief valve is provided on each turbine. This relief or waste valve is operated directly by the main governors and is automatically opened when the governor acts quickly to close the turbine gates. The relief valve gear can be adjusted to close in any desired time, so that the water wasted need be no more than sufficient to diminish the flow in the pipe line at a safe rate.

ELECTRICAL EQUIPMENT

Directly connected to each of the two turbines is a 3 phase, 25 cycle, 3,500 K.W., 13,200 volt Canadian General Electric generator. To each unit an exciter is directly connected, the capacity of each of which is sufficient for the excitation of the two main units. The generators and outgoing lines are controlled by means of Canadian General Electric H-3 motor operated oil switches from a switchboard also supplied by the Canadian General Electric Company.

For station purposes, a 100 K.W. step down transformer is provided. The switchboard and control station are located on an extension of the second floor of the annex, which projects into the generator room giving the operator a full view of the interior of the Power House. The switching apparatus is placed on the second floor of the annex.

Lightning arresters for the two outgoing lines are situated on the upper floor, and from these the lines pass out through the walls of the building in porcelain wall bushings. No step up transformers are used as the longest transmission line is less than six miles in length.

All of the electrical equipment within the Power House was supplied and installed by the Canadian General Electric Company.

At various places on the property, substations are provided in which are installed oil insulated water cooled transformers with a total capacity of 6,500 K.V.A., supplied by the Westinghouse Company.

All large motors are supplied with current at 2,200 volts; the smaller motors operate at 440 volts. For supplying the latter motors, Westinghouse transformers of 2,000 K.V.A. capacity, which step down the voltage from 2,200 to 440 volts, are provided.

All of the substation equipment was supplied by the Canadian Westinghouse Company.

For winding at the mine shafts and for driving compressors, etc., a number of large motors are provided, the largest of which is 750 H.P. These motors are of the 3 phase, 25 cycle, 2,200 volt type, and are either of the slip-ring or self-starting synchronous pattern.

The ventilating fans are driven by two 350 H.P. Westinghouse 3 phase, 25 cycle, 2,200 volt slip-ring motors running at 250 revolutions per minute, and are provided with Westinghouse automatic liquid self-starters. When for any reason power is cut off, the automatic liquid self-starters open the motor circuits, and when the power is restored the self-starters automatically connect the primary of the motor to the line; by means of a small motor the resistance in the secondary of the fan motor is gradually reduced, and the fan motor is thus slowly brought up to full speed, when its slip-rings are short-circuited.

The cost of the present development is slightly under $70.00 per horse power at the Power House switchboard. When the plant is completed to its ultimate capacity, the cost per horse power will be reduced to about $60.00.

Canadian Collieries (Dunsmuir) Ltd. End view of 8 foot Pipe Line.

Powell River Development. General view of Pipe Lines.

POWELL RIVER DEVELOPMENT
OF THE
POWELL RIVER COMPANY, LIMITED

THE situation of Powell Lake is particularly favourable for the development of a water power scheme. The lake is situated close to the sea coast; its original elevation before the construction of the works of the Powell River Company, Limited, was 246 feet above sea level; the area of the lake at this elevation is 65 square miles.

The Powell River Company, Limited, completed the installation of a pulp mill plant at Powell River in 1911. The minimum flow of Powell River was insufficient for the power requirements of this plant, but by the construction of a concrete dam, the spillway of which is 270 feet above sea level, sufficient storage was obtained.

Powell River Development. Dam and Intake Works. Powell River.

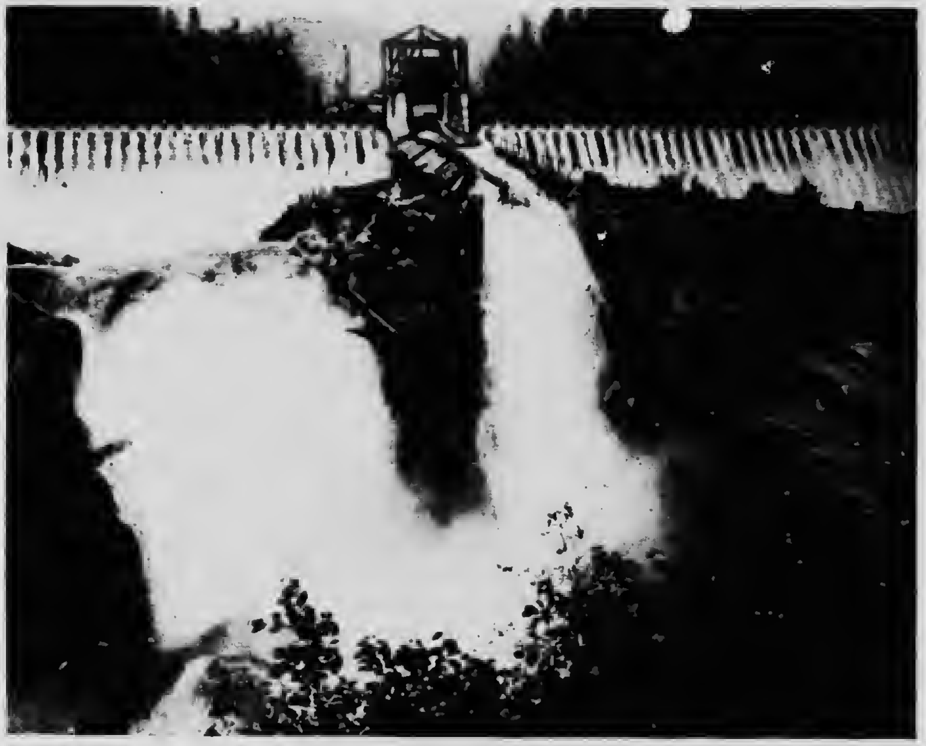
Powell River Development. General View of Paper Mill (taken before date of inspection).

A log sluice way is provided in the dam for the passage of logs over the dam, and guide booms to this sluice way are provided on the upstream side of the dam.

From the dam water is conveyed to the turbines in the Power House by means of three pipe lines. One of these pipe lines is of wood stave construction, the other two being of riveted steel.

The Power House equipment consists of two 1,875 K.V.A. 3 phase, 50 cycle, 600 volt Canadian General Electric generators, each direct driven at a speed of 375 revolutions per minute by an Allis-Chalmers-Bullock turbine of 3,000 H.P., and one 2,500 K.V.A. 3 phase, 50 cycle, 600 volt Canadian General Electric generator direct driven by a Platt turbine of 3,600 H.P. This unit also runs at a speed of 375 revolutions per minute.

In addition to these hydro-electric units, turbines are used for driving the grinders. There are two sets of seven pulp grinders each driven by a pair of Allis-Chalmers turbines, the capacity of each of which is 1,800 H.P. Two Platt turbines, each of 3,600 H.P., are provided for driving two other groups of grinders, each of which is made up of five machines.



Powell River Development. View of Dam showing the Fall from Log Sluiceway.

Powell River Development. General view of the Paper Mill (taken before date of inspection).

FALLS CREEK DEVELOPMENT
OF THE
GRANBY CONSOLIDATED MINING, SMELTING & POWER CO. LTD. AT ANYOX, B.C.

THE mining and smelting of copper is one of the principal industries of the Province of British Columbia. In 1894, the industry was practically non-existent; to-day more than 60 per cent. of the copper exported from the Dominion is mined in British Columbia. The growth of the industry has been greatly assisted by cheap power supplied by the development of the water power resources of the Province.

The Granby Consolidated Mining, Smelting & Power Company, Limited, has recently completed the hydro-electric development of Falls Creek to provide cheap power for the operation of its new copper mining and smelting plant at Anyox, B.C.

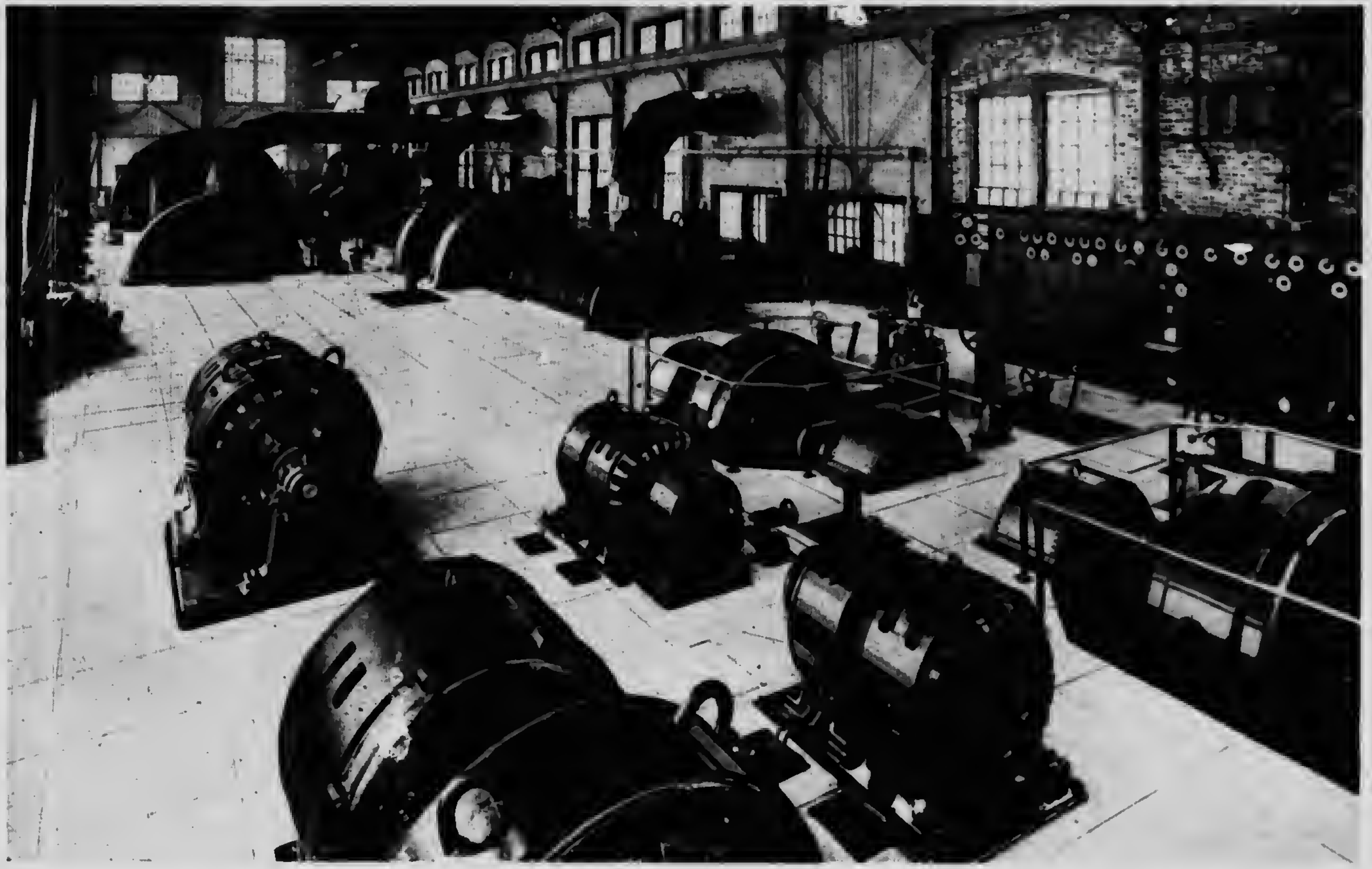
Falls Creek is a small mountain stream which flows into Granby Bay in Northern British Columbia; it drains a watershed of about 40 square miles over which the annual precipitation ranges from 70 to 100 inches, a large part of which is snow.

Storage of water formed an essential part of the scheme, as the minimum flow of the stream during the dry months of the year was far below the development contemplated. A suitable site for a storage dam was found just above an abrupt bend in the stream, in a rocky canyon 120 feet deep; at this point a rock filled dam was constructed with the crest at a maximum height of 115 feet above the bed of the stream, without unwatering the foundation. On the centre line of the dam at the inside bend of the creek a spillway 120 feet long is provided, excavated in solid rock; the crest of the spillway is 9 feet below the crest of the dam. The capacity of the spillway is considerably in excess of any known floods.

In the dam, an opening 72 inches in diameter controlled by a sluice gate is provided, to which is connected a 72 inch wood stave pipe 5,817 feet in length, the first 150 feet of which is in tunnel. This wood stave pipe is under a maximum static head of 298 feet; an open standpipe 12 inches in diameter is provided 4,000 feet from the intake. The radius of the bends is 400 feet. A steel pipe line 72 inches in diameter and about 120 feet long provided with the necessary branches, connects the lower end of the wood stave pipe line with the water wheels in the Power House. The working head at the Power House is 375 feet.

The Power House is a steel frame structure with brick curtain walls built on concrete foundations; it is 180 feet long and 50 feet wide, and contains five machines direct driven by water wheels for supplying air at various pressures for the operation of the mine and smelter, together with water wheel driven electrical units.

Granby Consolidated Mining, Smelting and Power Company Limited. Exterior view of Power House.



Granby Consolidated Mining, Smelting and Power Company Limited. Interior view of Power House showing Blowers and Compressors.

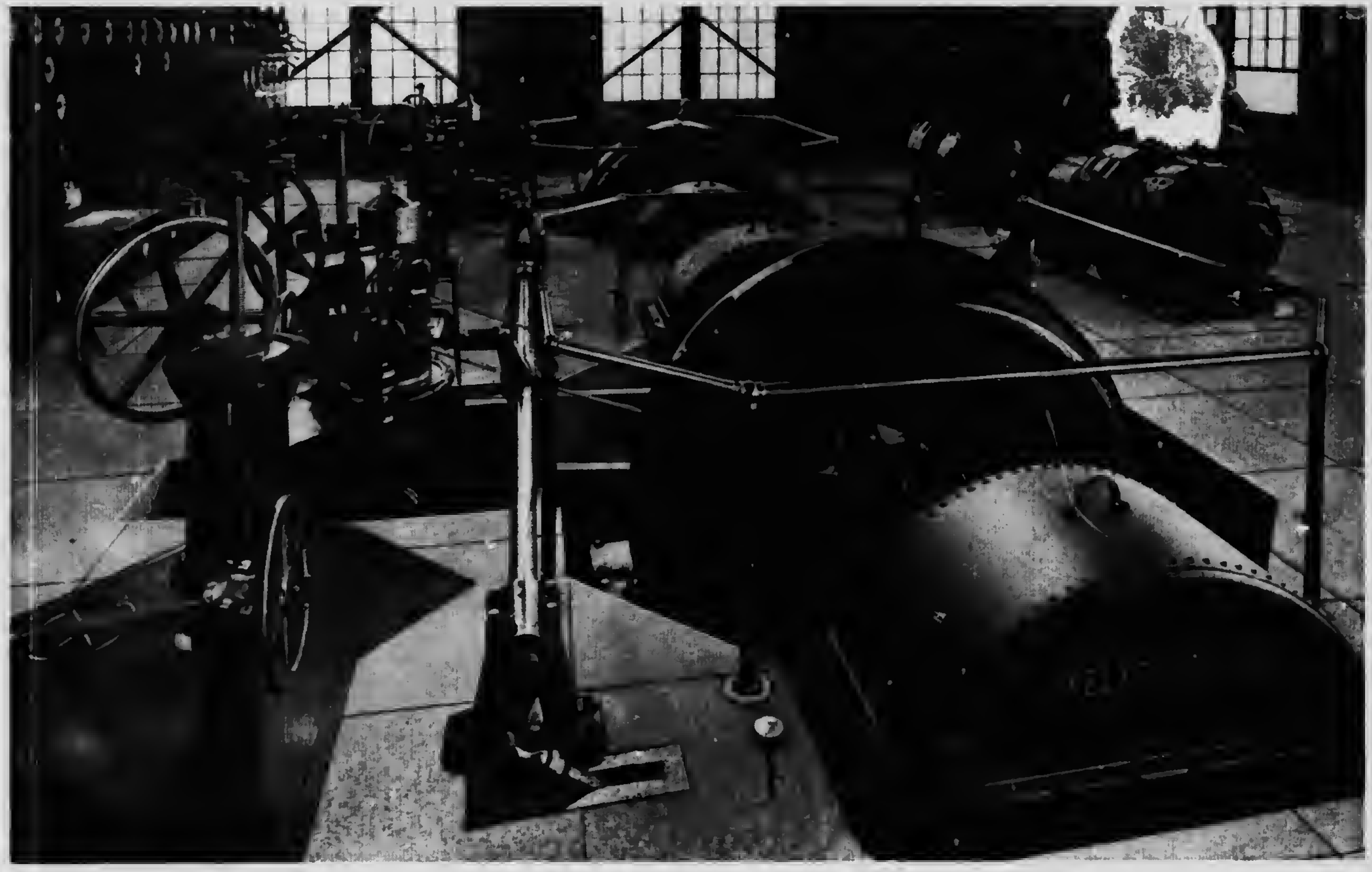
The electrical equipment consists of two 938 K.V.A., 3 phase, 60 cycle, 2,200 volt Westinghouse generators running at 400 revolutions per minute. Each unit is provided with two water wheel runners which are directly overhung upon the main drive shaft which is extended at either end beyond the bearings for this purpose. At the present time, either of the two generators is of sufficient capacity for the entire electrical load, so that one of the units may be shut down for repairs without interrupting the electrical service. For the excitation of the generators, two 50 K.W., 125 volt, 850 revolutions per minute, Westinghouse exciter sets are provided. One of these exciter sets is driven by an induction

Granby Consolidated Mining, Smelting and Power Company Limited. Front view of Power House.

motor at one end of the shaft, and by a single Pelton-Doble water wheel overhung at the other end; the water wheel is used for starting up the electrical equipment after a complete shut down. The second exciter unit consists of a 50 K.W., 125 volt, 850 revolutions per minute, generator driven by an induction motor, no water wheel drive being provided.

For supplying power to the electric locomotives used for haulage, and for other direct current motors, two Westinghouse motor generator sets are provided; each of these consists of a 440 H.P., 2,200 volt, 3 phase, 60 cycle induction motor direct connected to a 300 K.W. 550 volt interpole direct current generator running at 850 revolutions per minute.

Two 42 ton Baldwin-Westinghouse electric locomotives are used for hauling ore from the mine to the smelter, and for hauling freight from the wharf to the plant; each of these locomotives is provided with four motors aggregating 336 H.P., and has a starting tractive effort of 28,000 lbs.



Granby Consolidated Mining, Smelting and Power Company Limited. Interior view of Power House showing Water Wheel Driven Generating Units.

Granby Consolidated Mining, Smelting and Power Company Limited. 72 Inch Wood Stave Pipe Line on Trestle.

For smelter charge service three 12 ton Baldwin-Westinghouse electric locomotives are used, and four 6 ton locomotives are used for mine haulage.

Alternating current is transmitted to the mine at 2,200 volts; the motors on the crushers, and all other large motors are operated from the 2,200 volt circuit. The small motors operate at 220 volts.

A 16 panel switchboard is provided in the Power House for controlling the generators and the various power circuits; this switchboard, together with the rest of the electrical apparatus, was supplied by the Canadian Westinghouse Company.

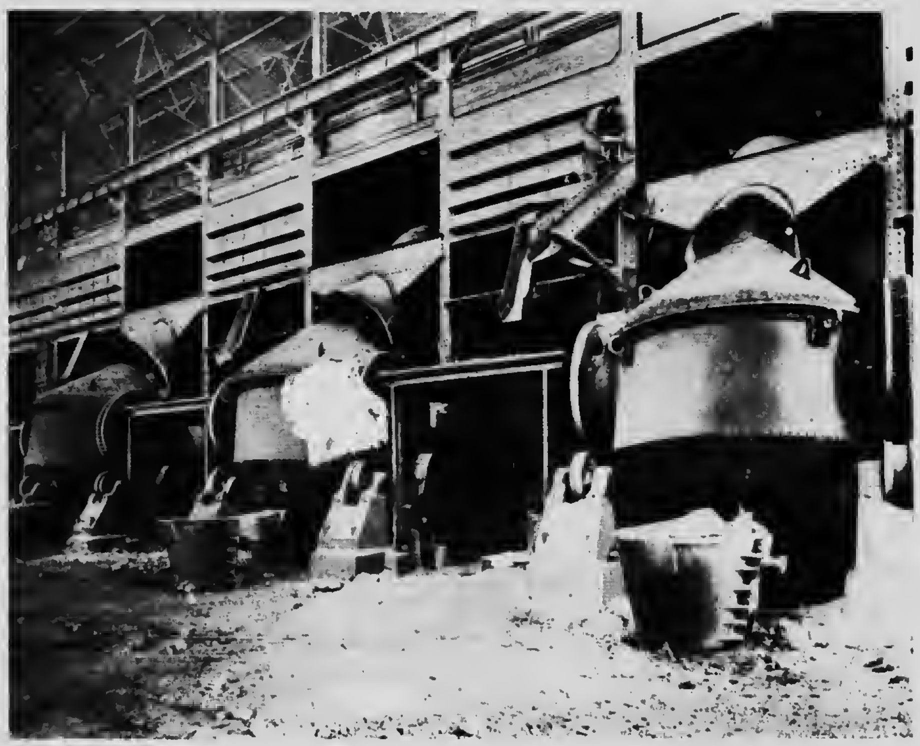
The air supply for the main blast furnace and the smelter is supplied by three Connersville positive blowers, each of which has a capacity for delivering 40,000 cubic feet of free air per minute against a pressure of 32 ounces and operating at a speed of 115 revolutions per minute. Each of these blowers is operated by means of a direct connected Pelton-Doble water wheel, 14 feet in diameter of 625 H.P. normal rating and with a maximum capacity of 775 H.P.

Granby Consolidated Mining, Smelting and Power Company Limited. 72 Inch Wood Stave Pipe Line under Winter conditions.

Granby Consolidated Mining, Smelting and Power Company Limited. Casting Machine.

The air required for blowing the Bessemer converters used in the refining of the copper matte at the smelter is provided by a Norvberg variable capacity two-stage water wheel driven blowing engine having a capacity of 12,000 cubic feet of free air per minute under a maximum pressure of 18 lbs. per square inch and operating at a speed of 75 revolutions per minute. This blowing engine has directly mounted upon its crank shaft, a Pelton-Doble water wheel 23 feet in diameter; this water wheel, in addition to supplying power for driving the blowing engine, furnishes the necessary fly-wheel effect to insure smooth operation. The blowing engine is of the reciprocating type and the maximum capacity of the water wheel is 1,400 H.P.

For supplying compressed air for the operation of tools at the Mine and elsewhere on the property, a Norvberg two-stage air compressor of the reciprocating type is provided; this compressor has a capacity for delivering 4,000 cubic feet of free air per minute at a pressure of 100 lbs. per square inch and operating at a normal speed of 84 revolutions per minute. This compressor is direct driven by a Pelton-Doble water wheel 16 feet in diameter and designed for an output of 800 H.P. The water wheel runner also provides the necessary fly-wheel effect.



Granby Consolidated Mining, Smelting and Power Company Limited. The Converters.

Granby Consolidated Mining, Smelting and Power Company Limited. The Smelting Plant.

Each of the five above-mentioned water wheels is provided with a Pelton oil pressure governor and with water economising auxiliary relief nozzles which reduce the rise of pressure in the pipe line to a minimum. The load on these water wheels is variable and quick governing is required in order to provide proper speed regulation. The opening of these relief nozzles is controlled by the speed governors. In the event of a sudden decrease of load requiring a rapid decrease in the volume of water discharged upon the wheel from the power nozzles, the power nozzles are closed and the relief nozzles are opened, thus providing a discharge outlet for the water flowing towards the unit. The relief nozzle then automatically closes; the rate of closing can be adjusted by means of a small by-pass on a dashpot on the auxiliary needle stem, so that the velocity of the water in the pipe line is reduced slowly, thus preventing any undue rise of pressure in the pipe line.

Each of the water wheel units is provided with a main gate valve fitted with a by-pass; these gate valves are so geared that they may be operated with facility by one man.

KOOTENAY RIVER DEVELOPMENT OF THE CITY OF NELSON

AT upper Bonnington Falls on the Kootenay River the City of Nelson has installed a hydro-electric power plant which provides light and power for the City and for mining purposes in the surrounding district.

The installation consists of one 750 K.V.A. and one 1,000 K.V.A. Allis-Chalmers, 3 phase generators, each driven direct by one 2,000 H.P. Allis-Chalmers Turbine; the speed regulation is controlled by an Allis-Chalmers oil pressure governor. The head available at the turbines varies from 40 feet to 60 feet depending on the stage of the river.

Current is transmitted at 12,000 volts from the Power House to Nelson, a distance of 10 miles, over a 2 circuit transmission line; these circuits consist of stranded aluminum cable and are carried on cedar poles.

BARRIERE RIVER DEVELOPMENT OF THE CITY OF KAMLOOPS

THE City of Kamloops, situated at the junction of the North and South Thompson Rivers, has recently completed the first portion of the hydro-electric development of the Barriere River, a tributary of the North Thompson River, to provide cheap light and power for the City, and to encourage settlement in the valley of the North Thompson, where the land is suitable for intensive farming provided cheap power for pumping water for irrigation is available.

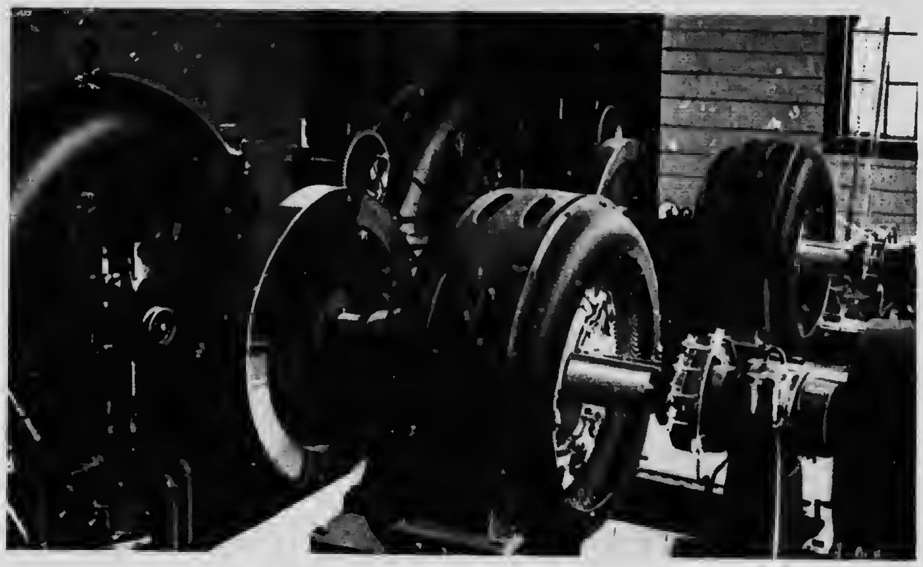
The Barriere River flows in general in a westerly direction and empties into the North Thompson at a point about 40 miles north of the City of Kamloops.

To provide the necessary storage, a dam was built at the outlet of Barriere Lake; from this point water is conveyed to the forebay through a flume 18,000 feet in length; from the forebay, which is fitted with sluice gates and provided with a spillway, the water is conducted through pipe lines to the Power House, which is situated on the north bank of the Barriere River.

The equipment in the Power House consists of two Francis turbines manufactured by the Platt Iron Works, and operating under a head of 190 feet, each of which drives a 750 K.V.A. generator of the 3 phase, 60 cycle type, which generate current at 2,300 volts.

The necessary low and high tension switching equipment is provided in the Power House, together with transformers which step up the voltage to 44,000 volts, at which voltage it is transmitted over a transmission line about 40 miles in length to the City of Kamloops; the voltage is transformed down at a substation which forms a portion of the auxiliary steam

City of Kamloops-Barriere River near Kamloops. Barriere Hydro-Electric Generating Station.



City of Kamloops-Barriere River near Kamloops. Interior of Barriere Hydro-Electric Generating Station.

turbine plant building. This steam plant has recently been completed and is intended for emergency purposes only. The pumping plant for the City Water System is also housed in this building.

All of the electrical equipment was supplied by the Canadian Westinghouse Company.

The Power House has been constructed of sufficient size for the accommodation of two additional units which will be added to as the load increases. The ultimate capacity of the development is 20,000 H.P.

The cost of the initial hydro-electric installation is about $140.00 per horse power: the installation of further 4,000 horse power will reduce the average cost per horse power to $90.00; it is estimated that when the ultimate development is carried out the average cost per horse power will be reduced to $80.00.

SIMILKAMEEN RIVER DEVELOPMENT OF THE HEDLEY GOLD MINING COMPANY AT HEDLEY, B.C.

THE Hedley Gold Mining Company's hydro-electric developments on the Similkameen River provide light and power for the operation of motors at the mines, and for compressors, crushers, stamps, vanners, pumps and various other machines in the stamp mill and cyanide plant where the gold ore is treated; direct current is also provided for electric locomotives.

There are two separate power houses in connection with this development.

PLANT No. 1

Water is diverted from the Similkameen River by means of a diversion dam formed of stop-logs supported by concrete piers; all of the stop-logs are easily removable in case of floods. From the diversion dam, the water is conveyed through 16,000 ft. of flume 9 ft. wide and 7 ft. deep to a forebay, thence through a steel pipe line 8 ft. in diameter to the Power House. The static head at the Power House is 67 ft.

The equipment consists of one 1,250 K.V.A. Canadian Westinghouse 3 phase, 60 cycle, 6,600 volt, 400 revolutions per minute, generator (with direct connected 25 K.W. exciter) coupled to a 2,100 H.P. S. Morgan Smith Turbine of the Francis type; standard generator and exciter switchboard panels are provided. Current is transmitted at 6,600 volts to the Mill 3½ miles distant, where the voltage is stepped down to 2,200 volts to enable the two plants to be run in parallel.

Plant No. 2 operates under a head of 412 feet. About 3 miles from Hedley, a dam is constructed which diverts water to a flume about 4 ft. wide and 4 ft. deep and about 13,000 ft. in length to a forebay; from this point, the water is taken to the Power House through a steel pipe line 20 ins. in diameter to 550 H.P. Doble water wheel driving direct a Canadian

Westinghouse 400 K.V.A. 3 phase, 60 cycle, 2,200 volt, generator at a speed of 150 revolutions per minute. A second 20 in. pioe line supplies water to a Knight water wheel driving a Canadian Ingersoll-Rand air compressor of capacity 3,000 cu. ft. of free air per minute.

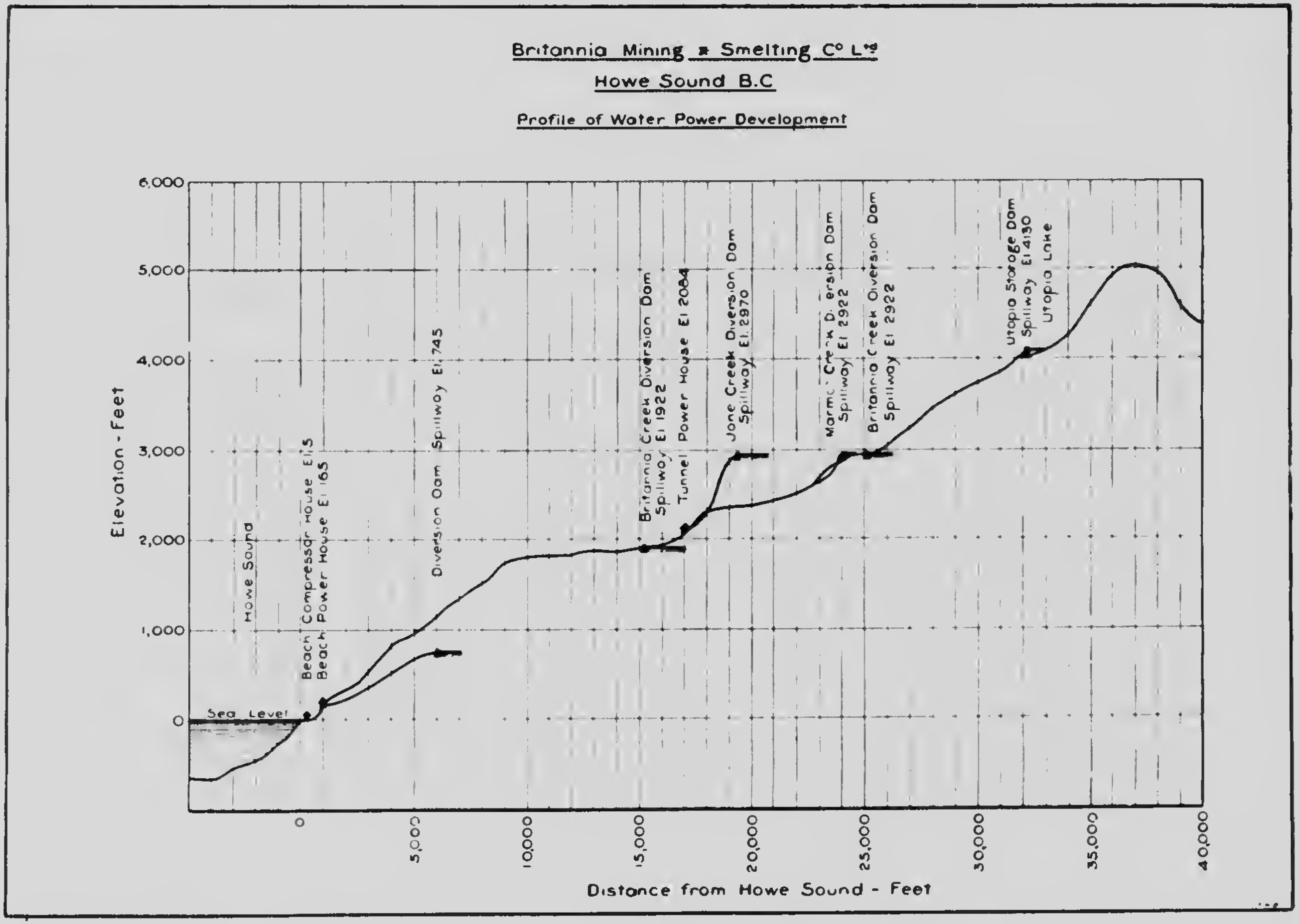
WATER POWER DEVELOPMENT OF THE BRITANNIA MINING & SMELTING COMPANY, LIMITED HOWE SOUND, B.C.

THE property of the Britannia Mining & Smelting Company is situated at Britannia Beach on the east shore of Howe Sound about 28 miles from the City of Vancouver, B.C.

Development work on this property for the mining and export of copper was started in the year 1905; since that date the plant has gradually been extended, and further development work, which will nearly quadruple the output of copper from the property, is now in progress.

Mining operations are carried on in the mountains about four miles from the beach of Howe Sound, B.C., and at an elevation of 3,500 feet above sea level. The copper ore as it comes from the Mine is crushed at the mouth of the Mine tunnel; it is then transported by means of gravity ærial tramways to bunkers behind the Reduction Mill, which are situated

Britannia Mining and Smelting Company, Limited. Downstream face of Utopia Dam during construction.



Britannia Mining & Smelting Co Ltd
Howe Sound B.C
Profile of Water Power Development
Elevation - Feet
6,000
5,000
4,000
3,000
2,000
1,000
0
Sea Level
Howe Sound
Beach Compressor House El 15
Beach Power House El 165
Diversion Dam Spillway El 745
Britannia Creek Diversion Dam
Spillway El 1922
Tunnel Power House El 2084
Jane Creek Diversion Dam
Spillway El 2970
Spillway El 2922
Britannia Creek Diversion Dam
Spillway El 2922
Utopia Storage Dam
Spillway El 4130
Utopia Lake
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
Distance from Howe Sound - Feet

Britannia Mining and Smelting Company Limited. Bridge carrying Electric Railway over Britannia Creek.

about 500 feet from the foreshore and about 160 feet above sea level. From these bunkers the ore is fed to the Reduction Mill, and after having passed through various crushing and washing processes the concentrated product is transported in trains of cars drawn by electric locomotives to bunkers on the Company's Wharf on Howe Sound, whence shipment is made to the smelting plant at Tacoma, Wash.

To provide light and power for the operation of the haulage and compressed air systems at the Mine, and for the motors and lighting at the Reduction Mill and throughout the Camp, a hydro-electric system has been developed comprising a compressor plant built on the foreshore of Howe Sound, 5 feet above sea level, and two hydro-electric generating stations named the Beach Power House and the Tunnel Power House, and situated 165 feet and 2,084 feet above sea level respectively. The water power available on the property has now been developed nearly to its ultimate capacity, until storage reservoirs now under construction are in service. It has, therefore, been found necessary to install one 500 K.V.A. steam turbine unit, and the installation of one 2,000 K.V.A. steam turbine unit is now in progress.

TUNNEL POWER PLANT

The Tunnel Power House is situated about three miles from the Beach House at Elevation 2,084. The Power House is a frame building 40 feet wide and 83 feet long, and the equipment is as follows:—

1–200 K.W., 3 phase, 60 cycle, 900 R.P.M., 6,600 volt Allis-Chalmers Generator, driven direct by one 330 H.P. Pelton-Doble water wheel. For excitation purposes, one 6½ K.W., 125 volt exciter is belted to the unit.

1 - 100 K.W., 3 phase, 60 cycle, 900 R.P.M., 6,600 volt Allis-Chalmers Generator, driven direct by one 130 H.P. Pelton-Doble water wheel. For excitation purposes, one 6½ K.W. 125 volt exciter is driven by belt from this unit. For trolley traction purposes, one 40 K.W. Westinghouse 250 volt, D.C. Generator is also belt driven from the main shaft of this unit.

One Air Compressor, capacity 700 cubic feet per minute, speed 120 R.P.M., belt driven by one Pelton-Doble water wheel of 125 H.P.

One Air Compressor, capacity 1,100 cubic feet per minute, speed 180 R.P.M., belt driven by one 200 H.P. Henry water wheel.

Britannia Mining and Smelting Company Limited. Utopia Lake and Utopia Dam with Spillway at Elevation 4100.

Water for driving these units is conveyed from Britannia Creek, Marmot Creek and Jane Cre[illegible] the Power House. Near the head waters of Britannia Creek a concrete dam 40 feet in height and 175 feet in length, has been built, creating available storage of 17,500,000 cubic feet for use during the dry months of the year, namely July and August, January and February. The lake thus created is known as Utopia Lake. The spillway of this dam is at Elevation 4,130. During these dry months, the flow in Britannia Creek is augmented from Utopia Lake as required, outlets in the dam with head gates having been provided for this purpose; these outlets discharge into the old stream bed. About 2½ miles below the dam a diversion dam on Britannia Creek is built, the elevation of the spillway being 2,922 feet above sea level; from the diversion dam water is conveyed to the Tunnel Power House through a pipe line 7,100 feet long, made up of 2,600 feet of 18 inch wood stave pipe, and 4,500 feet of 15 inch "Extra Heavy" lap welded steel pipe.

Britannia Mining and Smelting Company Limited. View showing Pipe Lines and Aerial Tramway.

Britannia Mining and Smelting Company Limited. "Half Way" Camp, two miles inland from Britannia Beach, 1900 feet above the sea level.

A diversion dam is built on Marmot Creek with spillway at Elevation 2,922, and from this point water is conveyed through 510 feet of 14 inch wood stave pipe and 690 feet of 12 inch wood stave pipe to the upper end of the 15 inch steel pipe of the main pipe line from Britannia Creek. This junction is effected at Elevation 2,590.

A third diversion dam has been built on Jane Creek with spillway at Elevation 2,970; water is conveyed from this point to a Y pipe on the main pipe line just behind the Tunnel Power House through 1,100 feet of 12 inch wood stave pipe, 700 feet of 12 inch lap welded steel pipe and 440 feet of 10 inch "Extra Heavy" lap welded steel pipe.

Britannia Mining and Smelting Company Limited. Aerial Tramway, conveying Copper Ore from Britannia Mine to the Reduction Mills on Howe Sound.

BEACH POWER HOUSE

The Beach Power House is a frame building 30 feet wide and 81 feet long, built on concrete foundations, the elevation of the floor being 165 feet above sea level. The Power House was built at this elevation in order that some of the water from the tail races might be available for use in the Reduction Mill, the new portion of which is immediately in front of the Power House. The water, on emerging from the tail races of the Tunnel Power House, enters a 24 in. wood stave pipe line 2,500 feet in length, through which the tail water is conveyed to a point in the bed of Britannia Creek, where a diverting dam, with spillway at Elevation 1,920, is situated; from this intake, water is conveyed to the Beach Power House through 6,000 feet of 18 inch wood stave pipe, 7,400 feet of 12 inch "Standard" lap welded pipe, and 500 feet of 10 inch lap welded pipe. The static head on this pipe line at the Beach Power House is 1,755 feet The following machines in the Beach Power House are supplied with water from this pipe line.

2–200 K.W., 3 phase, 60 cycle, 600 R.P.M., 6,600 volts, Westinghouse Generators, driven direct by 330 H.P. Pelton water wheels. To each of these machines is belted a 17 K.W., 250 volt exciter.

1–200 K.W., 3 phase, 60 cycle, 900 R.P.M., 6,600 volt Allis-Chalmers Generator, driven direct by 1–330 H.P. Pelton water wheel. To this machine is belted 1–6½ K.W. 125 volt exciter.

In connection with the Beach Power House, a second independent pipe line has been installed. The intake is on Britannia Creek, the spillway of the diverting dam being at Elevation 745. The water is conveyed from this point to the Beach Power House through 850 feet of 24 inch wood stave pipe, 1,000 feet of 18 inch wood stave pipe, 820 feet of 16 inch wood stave pipe, and 1,900 feet of 13 inch steel pipe, the combined length of which is 4,570 feet. Water is supplied by this pipe line to one Pelton-Doble water wheel, driving direct one 150 K.W., 250 volt, D.C. Crocker-Wheeler generator. Coupled to this unit is a 150 H.P., 220 volt induction motor. This motor will be used to drive the generator, should the water supply become insufficient for the entire plant.

Britannia Mining and Smelting Company Limited. General character of Watershed of Britannia Creek. Camera at Elevation 3,500, four miles from Beach.

Immediately behind the Beach Power House on the 15 inch lap welded steel pipe from the "745 foot Intake" a Y pipe is provided, to which is connected a 10 inch "Extra Heavy" lap welded steel pipe line; this pipe is about 400 feet in length, and conveys water to the concentrating mill at Elevation 50, where three Pelton water wheels, each of 100 H.P. are in operation.

A steel Y pipe is also provided on the 10 inch steel pipe conveying water from the "1,900 foot Intake" just behind the

Britannia Mining and Smelting Company Limited. Aerial Tramway conveying Ore from Britannia Mine to the Mills at Britannia Beach. Howe Sound is seen on the right of the picture.

Britannia Mining and Smelting Company Limited. Britannia Beach, B.C.

Britannia Mining and Smelting Company Limited. Development Camp at Britannia Beach, Howe Sound.

Britannia Mining and Smelting Company Limited. New Reduction Mill, with Beach Power House in rear and Beach Compressor House in foreground. The Aerial Tramway is seen on the side of the mountain.

Beach Power House, to which a 10 inch "Extra Heavy" lap welded steel pipe 600 feet in length is connected. From a Y in this 10 inch pipe a 6 inch pipe conveys water to the Beach Compressor House, where a Rand Compressor, capacity 2,500 cubic feet per minute, driven at a speed of 85 R.P.M. by a 400 H.P. Pelton water wheel, is installed. The elevation of the Compressor House floor is 5 feet above sea level (extreme high water). The water wheel in the Compressor House operates under a static head of 1,915 feet; the Compressor is rope driven from a pulley on the water wheel shaft.

The combined area of the watersheds tributary to Britannia Creek, Marmot Creek and Jane Creek, above the "1,900 foot Intake" amounts to 5.48 square miles. At the higher elevations the snowfall is very heavy, amounting to 15 to 20 feet.

In designing this development, the total precipitation over the whole watershed was assumed to be 60 inches, with a run off coefficient of 68 per cent.; this rainfall was based on that of the City of Vancouv[illegible], 28 miles distant, as no precipitation data in connect[illegible] with these watersheds w[illegible] [illegible]ble.

In January, 1914, a ra[illegible] [illegible] installed at the Beach Power House at Elevation 165, and since that date a continuo[illegible] of the precipitation has been obtained daily. The total precipitation from 1st January, 1914, to 31st December, 1914, recorded at the Beach Power House amounted to 23.00 inches of snow and 75.087 inches of rain.

In May, 1914, precipitation gauges were installed at the Tunnel Power House (Elevation 2,084) and at Britannia Mine (Elevation 3,275), and since then daily records of the precipitation at these stations have been kept. The precipitation for the months of June, July,

Britannia Mining and Smelting Company Limited. Tunnel Camp, Britannia Mine. Tunnel Power House (in centre) Dormitory and Machine Shop.

August, September, October, November and December, 1914, at the Tunnel Power House and at Britannia Mine is given below.

The Tunnel Power House and the Beach Power House are connected by a wood pole single circuit transmission line, consisting of three No. 2 copper wires, and the generators of the two plants are run in parallel. This transmission line is extended to Britannia Mine at Elevation 3,275, with No. 6 wire, and to the Beach Compressor House with No. 2 wire. At Britannia Mine, four 50 K.V.A., 6,600-220 volt oil insulated, self cooled transformers are installed to provide current at 220 volts for induction motors operating crushers, and for two motor-generator sets of 40 and 45 K.W. capacity, which provide D.C. current at 250 volts for trolley traction purposes. Two 50 K.V.A., 6,600-440 volt transformers are provided for the operation of an electric hoist. Pole type transformers of a total capacity of 25 K.W. are installed at the Mine for lighting.

Within the Beach Compressor House are installed six 150 K.V.A., 6,600-220 volt oil insulated self cooled transformers to provide current at 220 volts for the operation of motors in the Reduction Mill, Machine Shop, etc., and for all A.C. power required at the Beach Camp. In addition, pole type transformers are installed throughout the Camp for lighting purposes.

The total capacity of induction motors connected to the system amounts to 1,268 H.P., and transformers aggregating 1,847 K.V.A. are installed. Mining is carried on with three 8 hour shifts, and the Reduction Mill is operated continuously; the load factor is very nearly 100 per cent. A very complete telephone system is provided.

BRITANNIA MINING & SMELTING COMPANY, LIMITED, HOWE SOUND, B.C.

PRECIPITATION DURING 1914

Month	At Beach Power House Elevation 165		At Tunnel Power House Elevation 2,084		At Britannia Mine Elevation 3,275	
	Snow	Rain	Snow	Rain	Snow	Rain
January	18.75″	14.920″				
February	2.00	3.630				
March	2.25	6.350				
April	.....	5.320				
May	.....	1.480				
June	.....	2.080	....	2.10″	.....	3.24″
J ·	.....	0.480	....	0.85	.....	1.11
August	....	0.770	....	1.02	.....	0.99
September	.....	8.250	....	12.00	.....	12.73
October	.....	14.415	....	19.36	.....	20.89
November	.....	14.942	25.0″	No Record	43.68″	11.96
December	.....	2.450	3.5	3.5	30.50	.20
Total	23.00″	75.087″	28.5″	38.83″	74.18″	51.12″

NOTE:—The elevations given are heights above sea level.

WOODWORTH LAKE HYDRO-ELECTRIC DEVELOPMENT OF THE CITY OF PRINCE RUPERT

IN order to provide electrical energy for the City of Prince Rupert, the western terminus of the Grand Trunk Pacific Railway, the City Authorities have undertaken the development of Woodworth Lake water for power purposes, in conjunction with the extension of the water supply of the City.

Woodworth Lake is situated about 7 miles from Prince Rupert, and has an area of 500 acres; the mean run off available for the City's use at the present time is 75 cubic feet per second; additional water records aggregating 10,000 H.P. have been secured for future extensions. To utilize the run off from Woodworth Lake Watershed, a storage dam at Woodworth Lake, 35 feet in height, was built. A suitable Power House site was found about 7,500 feet from the Lake, giving a head of 330 feet at the Power House.

City of Prince Rupert-Woodworth Lake, near Prince Rupert.
Grade for 45 inch Pipe Line.

The initial installation consists of one 1,125 K. V. A., 3 phase, 60 cycle, 4,400 volts Canadian General Electric generator direct driven at a speed of 514 revolutions per minute by a water wheel of 1,650 H.P. capacity. The requisite flywheel effect is provided by a cast steel flywheel weighing 8,000 lbs., and a governor operated by oil pressure ensures close regulation. For excitation purposes, a 15 K.W. direct current generator connected to the main unit is pro-

City of Prince Rupert-Woodworth Lake, near Prince Rupert. Woodworth Lake.

City of Prince Rupert-Woodworth Lake, near Prince Rupert. Dam under construction.

vided. The voltage is regulated by a Tirrill Regulator. The generator and outgoing line are controlled from a 3 panel switchboard.

All of the electrical equipment was supplied by the Canadian General Electric Company.

Water is supplied to the unit from Woodworth Lake through a pipe line 45 inches in diameter and 7,800 feet long. This pipe line is partly used for water supply purposes. Immediately behind the Power House on the 45 inch pipe, an 18 inch connection is provided to which is connected an 18 inch steel pipe line 14,000 feet long, which connects with an existing 18 inch water supply pipe near the auxiliary pumping station at Shawatlans Lake, about 5 miles from the City.

City of Prince Rupert-Woodworth Lake, near Prince Rupert.
45 inch Pipe Line with 45 inch Valve in position.

City of Prince Rupert-Woodworth Lake, near Prince Rupert. 45 inch Piper ready for transportation up Shawatlan's Lake.

City of Prince Rupert-Woodworth Lake, near Prince Rupert. 45 inch Pipe Line.

City of Prince Rupert-Woodworth Lake, near Prince Rupert. Front view of Power House.

City of Prince Rupert-Woodworth Lake, near Prince Rupert. Clearing for Pole Line right-of-way.

Energy is transmitted to the City over a single circuit wood pole transmission line.

Work was commenced in January, 1914, and the plant was placed in operation in November, 1914, since when it has been in continuous operation and has given entire satisfaction.

SWANSON CREEK DEVELOPMENT OF THE SWANSON BAY FORESTS, WOOD PULP & LUMBER MILLS, LTD.

THE plant of the Swanson Bay Forests, Wood Pulp & Lumber Mills, Limited, is favourably situated on Swanson Bay about 130 miles south of the City of Prince Rupert; comprises a Sulphite Pulp Mill, a large Saw Mill, and Wharves suitable for loading and unloading large vessels.

Power is provided for the operation of some of the machinery by turbines aggregating 1,250 H.P. operating under a head of 132 feet. A diversion dam has been built on Swanson or Yule Creek, and from this point the water is conveyed to the turbines through a pipe line. The turbines were supplied by the S. Morgan Smith Company.

The ultimate capacity of the plant is about 12,000 H.P.

HYDRO-ELECTRIC DEVELOPMENT OF THE CITY OF REVELSTOKE ON THE ILLICILLIWAET RIVER

THE Illicilliwaet River has its source in the Illicilliwaet Glacier at an elevation of 8,000 feet above sea level, and flowing in a south-westerly direction discharges into the Columbia River near Revelstoke. The drainage area is about 480 square miles, and the precipitation varies from 40 inches at the mouth to 100 inches at the source. The winters are very severe, with a tremendous snowfall; the temperature falls to 50° F. It is a typical mountain stream, with the flow varying from 250 cubic feet per second to over 9,000 cubic feet per second.

The hydro-electric development of the City of Revelstoke is on the Illicilliwaet River. A concrete dam across the canyon enables a head of 72 ft. to be obtained at the Power House about 800 ft. downstream from the dam.

Within the Power House are installed two units supplied by wood stave pipes, the intakes of which are controlled by sluice gates in the dam.

The first unit consists of a 450 K.V.A. Canadian Westinghouse generator driven by a 900 H.P. Francis turbine at a speed of 450 revolutions per minute. The second unit is made up of a 750 K.V.A., 360 revolutions per minute, Canadian Westinghouse generator direct connected to a 1,400 H.P. Escher-Wyss turbine of the Francis type, with double discharge; speed regulation is controlled by an oil pressure governor. Exciter units are in each case direct connected to their respective generators.

These units generate 3 phase, 60 cycle current at 2,300 volts for use in the City of Revelstoke, and for the shops of the Canadian Pacific Railway Company.

HYDRO-ELECTRIC DEVELOPMENT ON JUNIPER CREEK AT SKEENA CROSSING

IN connection with the development of a high grade copper proposition owned by the Rocher de Boule Copper Company, and which is under lease to the Montana Continental Development Company, a small hydro-electric plant has been installed on Juniper Creek about 4½ miles from Skeena Crossing.

A 187.5 K.V.A. Canadian General Electric 3 phase, 60 cycle 2,300 volt generator, belt driven by a Pelton-Doble water wheel has been installed.

Water is obtained from an intake on Juniper Creek and is conducted to the Power House through a wood stave pipe line 3,783 feet in length, made up of 1,000 feet of 24 inch pipe, 1,000 feet of 22 inch pipe, 1,000 feet of 20 inch pipe, and 783 feet of 18 inch pipe. The maximum heads on these pipes are respectively 50 feet, 100 feet, 150 feet and 212 feet.

The effective head at the water wheel nozzles when the unit is operating under full head is 178 feet.

Shipment from this mine will be made as soon as the ore bunkers at Prince Rupert have been completed.

FORTUNES CREEK DEVELOPMENT AT ARMSTRONG

THE Municipality of Armstrong owns and operates a hydro-electric plant on Fortunes Creek which provides

Fortunes Creek Development Pipe Line near Power House.

light and power for the City of Armstrong. The water supply of the City is also obtained from this Creek.

Fortunes Creek, also known as Davis Creek, is a stream about 15 miles long, rising in the hills northeast of Armstrong at an elevation of 3,500 feet, and discharging into the Shuswap River. The mean annual precipitation over the Fortunes Creek drainage area is about 20 inches with about 6 feet of snow. The flow of the stream is variable, and for three months in the year the discharge is so small that an auxiliary Diesel Engine Set is used to provide the necessary power during these months.

A timber crib diverting dam forms an intake for a wood stave pipe line which is joined to a 10 inch steel pipe line at the top of the cliff behind the Power House.

The equipment consists of a [illegible] K.W. Canadian Electric generator driven direct at a speed of 900 revolutions per minute by a 150 H.P. Pelton water wheel. The Diesel Engine Set consists of a 200 H.P. Diesel Engine driving a 125 K.W. generator. Both units are of the 3 phase, 60 cycle type and generate current at 2,300 volts. A three panel switchboard is provided for controlling the Power House equipment.

Murray Creek Development Power House, near Spence's Bridge.

HYDRO-ELECTRIC DEVELOPMENT ON MURRAY CREEK, NEAR SPENCE'S BRIDGE

MURRAY CREEK is a small stream which rises in the Murray Mountains at an elevation of 4,000 feet above sea level, and flows south-east discharging into the Thompson River at Spence's Bridge at an elevation of 700 feet; it is about 10 miles in length. The precipitation over the watershed does not exceed 20 inches.

About a quarter of a mile from the mouth of this Creek there is a fall over 200 feet in height; at the crest of this fall a small timber dam has been constructed which diverts the water from the stream into a tunnel 200 feet in length. To the lower end of this tunnel a pipe line 10 inches in diameter is connected, which conveys water to the Power House.

The Power House is a concrete building 34 feet in length and 24 feet wide; the static head at the Power House is 255 feet. The generating machinery within the Power House consists of a 75 K.W., 6 pole, single phase alternator running at 200 revolutions per minute, which is belt driven by a Pelton water wheel running at 250 revolutions per minute. The speed is controlled by a Pelton governor which operates a jet deflector. Excitation is accomplished by a separate exciter unit running at 1,800 revolutions per minute which generates current at 125 volts.

The energy is transmitted to Spence's Bridge, a distance of about three-quarters of a mile, at 7,500 volts, and is there transformed down to 110 volts for lighting purposes.

Illicilliwaet River Development at Glacier. View of Power House in Winter.

HYDRO-ELECTRIC DEVELOPMENT AT GLACIER

THE waters of the Illicilliwæt River are also used at a small hydro-electric installation at Glacier, the electric energy being used for lighting the Canadian Pacific Railway Hotel at that point on its transcontinental line.

The Power House is a frame building 21 feet long by 17 feet wide, and provides accommodation for two 25 K.W., 125 volt generators, each of which is belt-driven by a turbine of 50 H.P. at a speed of 1,050 revolutions per minute. The head utilized is 90 feet. Current is transmitted to the Hotel over a transmission line 1,800 feet long.

Illicilliwaet River Development at Glacier. Front view of Power House.

Illicilliwaet River Development at Glacier. Dam under Winter conditions.

Illicilliwaet River Development at Glacier. Downstream face of Dam.

Cathedral Creek Development. Pipe Line.

Illicilliwaet River Development at Glacier. Side view of Dam.

WATER POWER DEVELOPMENT AT FIELD

THE Mill of the Mount Steven Mining Syndicate is operated by power derived from the development of Cathedral Creek, a small tributary of the Kicking Horse River near Field, B.C., on the main line of the Canadian Pacific Railway.

A small diverting dam 9 feet high provides an intake for a wood stave pipe line 12 inches in diameter and 1,700 feet in length, which delivers water to a 100 H.P. Pelton water wheel under a head of 300 feet. The main shaft in the Mill is driven from a pulley 36 inches in diameter on the water wheel shaft.

Prior to the installation of this water wheel, steam power was used to drive the Mill machinery, and it has been found that a very great reduction in operating expenses has been made since the water wheel was installed.

Cathedral Creek Development. Concentration Plant and Power House, Mount Stephen Mine.

1. North End Upper Lillooet Lake.
2. Little Qualicum River.
3. Seven Miles of Great Central Lake, B.C.
4 Cameron Lake.

1. Stamp River.
2. Hazel Creek, Mackenzie Fall, Toba Inlet. 800 feet fall in view. Typical of many streams as they decend from "hanging valleys."
3. Little Qualicum River.
4. Chehalis River Bridge at Upper Canyon.

NASS RIVER DEVELOPMENT OF THE KINCOLITH PACKING COMPANY, AT MILL BAY

THE Kincolith Packing Company owns and operates a cannery at Mill Bay in Northern British Columbia, and to provide power for the operation of this cannery during the fishing season a small water power development utilizing the waters of Nass River has been constructed.

The Nass River is fed by three small lakes at an elevation of about 360 feet above sea level. An 18 foot dam has been constructed at the outlet of one of these lakes, and a 10 foot dam at the outlet of the lake nearest the cannery.

The water wheel equipment consists of three Pelton water wheels, each of about 30 H.P. capacity, and one 90 H.P. Pelton water wheel. The length of the pipe line between the intake and the cannery is about 2,000 feet; the static head at the water wheels is about 330 feet.

The operating results of the Company indicate that this water power development is a financial success.

UNDEVELOPED WATER POWERS

IN a country so vast as British Columbia, with its great unpopulated and unexplored areas, it is impossible to do more than briefly refer to some of the undeveloped water powers which have been examined by the Canadian Commission of Conservation, the Dominion Water Power Branch of the Department of the Interior, Ottawa, the Water Rights Branch of the Lands Department of the Provincial Government of British Columbia, and by private enterprise. Much information, however, is available and will be willingly placed at the disposal of bona fide inquirers by responsible officials of the various Government Departments.

In the lower mainland of the Province within a reasonable distance of the port of Vancouver, in addition to the large powers that have already been described in the preceding pages, there are many other large powers awaiting development. Among those that may be referred to are Lillooet Lake (now called Allouet) 30 miles east of Vancouver, where it is possible to develop 25,000 H.P. economically by means of a storage dam at the outlet of the lake, and a flume line six miles long conveying the water to a point six miles westerly where a head of 290 feet will be available at a power house site near the tidal waters of the Pitt River. Farther up the Fraser River is its tributary the Chehalis River with possibilities of 30,000 to 40,000 H.P.; and going still further east, about 90 miles from Vancouver is Jones Lake that will give 35,000 H.P. under a head of 2,200 feet. Near this power is also the Chilliwack River and Lake with possibilities of a further 80,000 H.P., and going still

1. Great Central Lake, B. C., Near mouth of Stamp River.
2. Looking up Sproat Lake, V. I., from Sterling.
3. Cameron Lake, Vancouver Island, B C.
4. The Head of Great Central Lake, B. C.

further east we find the Coquihalla River, capable of developing 20,000 H.P. North of Howe Sound along the line of the Pacific Great Eastern Railway is the Cheakamus River and Falls, with a possible development of 50,000 H.P.

A very interesting undeveloped power project in the vicinity of Vancouver is that proposed by the Westminster Power Company, which contemplates two developments, one on the Meslilooet or Indian river with a head of approximately 400 feet, and another using the flowage from three tributary creeks of the Indian River under a head of approximately 2,000 feet. The two proposed developments are close together about three miles from the head of the North Arm of Burrard Inlet and about 20 miles from Vancouver. It is understood that a total of about 40,000 H.P. is possible of development.

The basin of the Fraser River* and its extensive tributaries offer a great field of study for the utilization of many water powers. The Fraser River is 695 miles long and receives the drainage of an area of 91,700 square miles. Of its principal tributaries, the Thompson drains 21,800 square miles and is 270 miles long; the Chilcotin drains 7,500 square miles and is 145 miles long; the Black Water drains 5,600 square miles and is 140 miles long; the Nechaco 15,700 square miles and is 225 miles long; the Stuart is 220 miles long; the North Thompson 185 miles, and the South Thompson 120 miles. The Fraser River rises near the summit of the Yellow Head Pass at an altitude of 3,710 feet. In 52 miles it falls to 2,400 feet near Tete Jaune Cache; thence, flows north-west in the "Inter-montane" valley to latitude 54°; then, like the Columbia at the "Big Bend", it turns westward and southward. At Fort George, near its most northerly point, it is at an altitude of 1,900 feet—a descent of 500 feet in about 200 miles. Steamers have ascended it to Tete Jaune Cache, a circumstance which indicates a swift-flowing stream without considerable fall at any point. The Grand Trunk Pacific grade on its banks would probably debar extensive damming except below the mouth of Bear River. During the season of navigation, steamers ply between Fort George and Soda Creek, which would, for the present, prevent the utilization of power sites on this stretch—such as Cottonwood canyon. The construction of the Vancouver branch of the Grand Trunk Pacific railway down this river, however, will, probably, result in the abandonment of this steamship line. Below Chimney Creek, the river enters the Fraser canyon to emerge near Hope. Between Fort George and Lillooet, about 255 miles, it falls 1,240 feet. Allowing a fall of, say, 3½ feet per mile for the 150 miles between Fort George and Chimney Creek, there is left a descent of nearly 740 feet in the 105 miles between the latter and Lillooet. Between Lillooet and Lytton bridge, it falls 244 feet in 40 miles, and between the bridge and Hope, it falls 300 feet in 60 miles, having an altitude at Hope of about 115 ft. above sea level.

Below Lytton, irrespective of the difficulty—if not impossibility—of harnessing this raging torrent, the presence of the Canadian Pacific and Canadian Northern lines debars any attempt to generate power in this portion of its course. Above Lytton, as indicated above, there is even a greater fall per mile than below; but here, again, the construction of

* For much of this information regarding undeveloped powers, the writer is indebted to "Water Powers of Canada," by L. G. Denis and A. V. White, published by the Commission of Conservation, Ottawa, 1911.

1. Jones Lake looking North.
2. Jones Lake from Tunnel Pass.
3. Bute Inlet. Showing Mt. Superb, 8000 feet. Typical view on coastal inlets, B.C.
4. Stamp River Falls.

the Vancouver branch of the Canadian Northern Pacific may make it impossible to utilize this stretch—irrespective of the difficulties connected with the handling of the flow of a great river that has, in places, a range of 50 feet between high water and low water.

The Thompson is the largest affluent of the Fraser. It is 270 miles long—to the head of the North Thompson—and drains an area of 21,800 square miles. The foregoing remarks respecting the Fraser River canyon apply in large measure to the canyon of the Thompson above its confluence with the Fraser. The North Thompson—main branch—is 15[illegible] miles long and rises near Tete Jaune Cache, at an altitude of about 2,400 feet. Forty miles below, at the head of the canyon it is at elevation 2,066, a descent of 336 feet—eight feet per mile. At the "stillwater" below the canyon it is 1,925 feet, a fall of 141 feet in four miles. At its confluence with the South Thompson, near Kamloops, it is at altitude 1,133, a descent of 1,267 feet in the 170 miles from the head-waters. The Raft, Mad, Blue and Clearwater tributaries are important streams with steep descent.

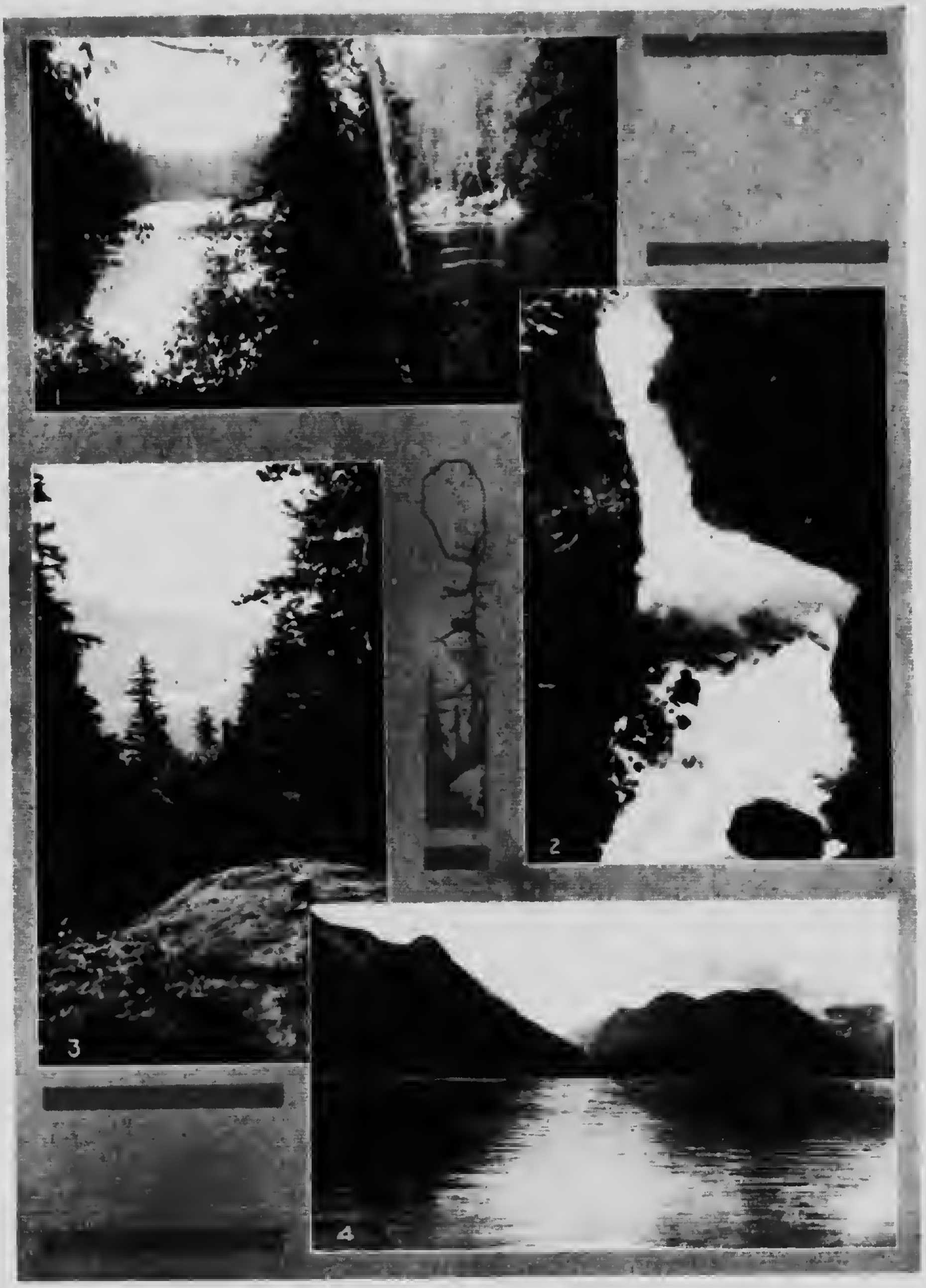
The South Thompson is 120 miles long. It is navigable from Kamloops to Shuswap lake and contains no water powers. Its upward continuation, the Shuswap, falls 130 feet between Enderby and Mable Lake. It drains Mable lake, a reservoir 20 miles long and from half a mile to a mile wide. Adams river carries the discharge of Adams lake, a magnificent sheet of water, 37 miles long and one and a half miles wide. Between Adams lake and the South Thompson, the river descends 220 feet in five miles. The proposed installation on this stream will utilize a head of 165 feet.

Of the powers that have been explored within this watershed, the project of the Couteau Power Company deserves attention, as it is proposed to proceed with this project at an early date.

The development is situated in the Osoyoos Division of Yale District, in the Province of British Columbia. The site of the initial and main power plant at the Shuswap Falls, on the Spillimacheen River, lies 26 miles due east of the City of Vernon, and nine miles east of the small town of Lumby, at an elevation of 1,500 feet above sea level. The Spillimacheen River flows from Sugar Lake, 20 miles north-east of the site, while Sugar Lake will provide storage for the full development which, situated as it is in the "dry belt," will be essentially a storage proposition.

The drainage area above Shuswap Falls, mainly mountainous country difficult of access amounts to between 800 and 900 square miles. Rainfall records have been taken uninterruptedly for the last ten years at a point distant 20 miles west and at the same altitude, giving an average annual total precipitation of 12 inches. The Couteau Power Company's Hydrographers, operating for the last three years at Shuswap Falls, return an average annual precipitation there of 20 inches, including an average annual total of 45 inches of snowfall at Shuswap Falls and 90 inches at Sugar Lake, with an average maximum lying depth of 3½ feet and 6½ feet respectively. At both places the ground is bare of snow from the middle of April to the middle of November.

Sugar Lake, at an elevation of 2,080 feet above sea level, has an area of 3,786 acres, is 4½ miles long by 2½ miles at the widest, and is frozen over entirely from the beginning of January to the middle of April. It is fed by the Spillimacheen, Sitkum and Outfall Creeks



1. Irene Pool, Campbell River, B.C.
2. Elk Falls, Campbell River, B.C.
3. Chehalis Lake, looking South
4. Lillooet Lake (Lower) looking North

and supplies 75% of the river discharge at Shuswap Falls, the remainder being contributed mainly by the only two creeks of consequence between the Lake and Shuswap Falls, Cherry Creek and Eight-mile Creek. Apart from a small area of flat land at each end the shores rise quickly and are densely wooded. After a fall of 38 feet at the Lake outlet, the river flows on even grade through the 20 odd miles to the gorge above Shuswap Falls where, with a series of rapids extending over half a mile, the river drops 70 feet in that distance.

The river discharge averages 350 to 400 second feet during January, February and March, rising to a peak in the middle of June of between 6,000 and 13,000 second feet, dropping thence uniformly to 2,000 second ft. in August, and then gradually to 400 second feet in December.

During November and December minimum temperature hovers around 32° F., and during January and February fluctuates between freezing point and 10° below zero. Maximum temperature rises uniformly from 40° F. in March to a peak of 90° in July, and then falls also uniformly to 40° at the end of November. Ice conditions on the river are at their worst between the third week in December and the second week in February, anchor ice forming periodically accompanied by frequent flow of frazil. The river channel is usually free of ice by the middle of March.

The development, in design, is divided into four progressive phases to take shape in turn, as increasing market calls shall require. The first, with an overflow intake dam containing 16,000 cubic yards of concrete, a net head of 130 feet, and one line of 3,750 feet of 96 inch steel pipe to the Power House at Shuswap Falls, will provide 4,000 continuous H.P. with a peak capacity of 7,000 H.P. The second, with two lines of 96 inch pipe at Shuswap Falls, and storage provided by raising the surface of Sugar Lake 18 feet, will supply 8,000 continous H.P. with a peak capacity of 13,250 H.P. The third, with three lines of 96 inch pipe at Shuswap Falls, and storage provided by raising the surface of Sugar Lake 40 feet, will supply 12,000 continuous H.P. with a peak capacity of 19,880 H.P. The fourth phase, by the installation of an additional plant at the foot of the Sugar Lake dam, operating under a head of 70 feet and using, as it passes, the water being drawn from storage to feed the Shuswap Falls plant 20 miles lower down the valley, will bring the grand total of power to be provided by the development to 18,000 continuous H.P. with a peak capacity of 28,880 H.P. The dam at Sugar Lake will be placed and designed to allow of an eventual increase of height to 80 feet to provide storage for the possible doubling of that output.

The prospective light and power market in the Okanagan Valley is attractive and that demand, coupled with the electrification of the proposed 180 miles of extensions, through the district, of the Canadian Northern Pacific Railway Company, will amply justify the prosecution of the development. The produce shipped from the valley in 1912 amounted to 1,900 carloads. There are at present 17,400 acres of planted orchards in the Okanagon of which only 32% are over five years of age. On a conservative basis, assuming even no further planting, expert calculation definitely places the export of fruit alone in the year 1920 at 7,000 carloads, allowing liberally for orchard losses by disease and misadventure, and in the year 1925 at 12,000 carloads.

1. Sun Set, Campbell River, B.C.
2. Little Qualicum River.
3. Campbell River, B.C.
4. K 55, Adams Lake looking North.

The proposed Canadian Northern Pacific Railway Company's branch line in the Okanagan will deliver all construction material at the site of the proposed plant; climatic conditions are peculiarly favorable for rapid and economical construction; while a prosperous producing district of British Columbia eagerly awaits the distribution of cheap light and power.

Among other rivers that may be referred to is Cayoosh Creek, which empties into the Fraser opposite Lillooet village. Between Anderson and Seton lakes, it falls 58 feet in four miles, and between Seton lake and the Fraser there is a descent of 134 feet in seven miles. Bridge river is a considerable tributary and drains a portion of the Coast range to the north of Cayoosh creek. By driving a tunnel from the valley of the latter, a head of 1,500 feet could be obtained.

The Chilcotin river drains an area of 7,500 square miles and is 145 miles long. Between Puntzee lake in its upper waters, and the mouth, it falls 1,750 feet. Its south branch, the Chilko, falls about 2,400 feet between Chilko lake and the Fraser. As Chilko lake is about 50 miles long and from four to five miles wide, there is excellent storage available.

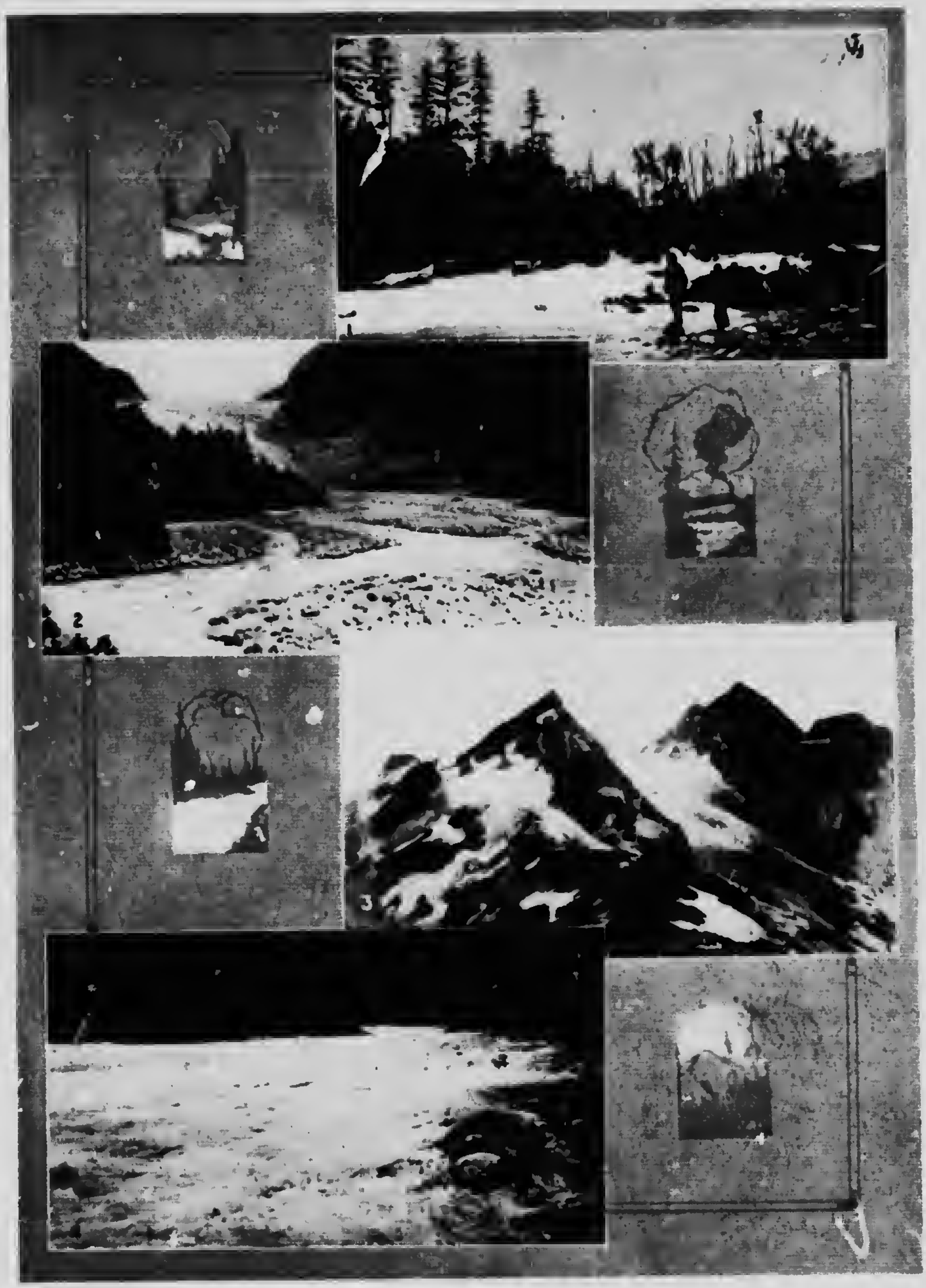
The Quesnel river drains the southern portion of the Cariboo mountains. Between Quesnel lake and the mouth it falls 350 feet. Between Cariboo lake and the Fraser, its north branch falls 650 feet. Quesnel lake, 60 miles long and three miles wide, would provide excellent storage.

The Blackwater river drains an area of 5,600 square miles and 140 miles long. It falls about 1,700 feet between Tsacha lake an expansion and the Fraser.

The Nechaco drains an area of 15,700 square miles and is 255 miles long. Between Ootsabunkut lake and the Fraser, it falls 860 feet, of which 82 feet is in the short stretch between Ootsabunkut and Natalkuz lakes. Its north branch, the Stuart, is 220 miles long. The Nechaco basin contains a number of large lakes, including Ootsabunkut 40 miles long, Cheslatta 25, Francais 60, and Fraser 12 miles; also Stuart lake with an area of 221 square miles, and Tacla 135 square miles.

On the north fork of the Fraser, about 35 miles from its confluence with the main stream, there is a fall 80 feet high.

The Columbia river has a total length of 1,150 miles, of which 465 miles are in Canada. It drains, in Canada, an area of 39,300 square miles. It rises in Upper Columbia lake in the great "Inter-montane" valley between the Rockies and the Selkirks. From the lake, it flows northward to latitude 52°, turns westward at the "Big bend" to flow round the north end of the Selkirks, then flows southward through the valley between the Gold range and the Selkirks. Above Golden, it is a sluggish, navigable stream and, therefore, not available as a source of power. The tributaries that fall in from the east are small mountain torrents of little value from a power standpoint. The Dutch, Toby, Salmon and Spillimacheen are important tributaries with a large low-water discharge from the glaciers and snow-fields of the Selkirks. The Beaver, a western tributary and the Kicking Horse, an eastern branch, carry a large volume of water, but owing to the construction of the Canadian Pacific Railway along their banks, economic development on a large scale might be difficult. The Blaeberry is an important stream and falls nearly 2,000 feet between its source



1. Adams River Lumber Co's Dam
2. Ice River, Glacier. Many of the Rivers entering the Inlets have their sources in glaciers.
3. Mountains and Glacier, Jones Lake Watershed
4. Kiltuish River, Gardner Canal. Very typical of many of the coastal streams, as they course through the narrower valleys

in the Howse pass and the Columbia. Wood river and other tributaries of Canoe river, are glacier-fed torrents and, doubtless, contain many valuable powers; similarly with Goldstream, Downie, Carnes, Incomappleux, Illecillewæt and other streams that fall in below the "Big bend," although the same remark applies to the last named as to the Beaver.

The Kootenay has a total length of 400 miles, drains an area of 15,500 square miles and rises in the Rocky mountains about 20 miles south-east of Leanchoil station on the Canadian Pacific. As, in the upper portion of its course, it flows in a great valley parallel to the upper Columbia, then crosses the ranges to get into the "Inter-montane" valley and then, follows this valley, it is probable that most of the large powers must be looked for where it crosses the ranges. The Simpson, Cross, Palliser, White, Bull, St Mary, Elk and other tributaries of the Kootenay, are large streams with heavy falls and rapids.

The Kootenay follows the "Inter-montane" valley southward into Montana, turns westward and then, northward into Canada, to empty itself into Kootenay lake, thence westward to its confluence with the Columbia. Between Kootenay lake and the Columbia it falls 350 feet in 25 miles, affording many valuable powers. The Slocan, Lardeau, Duncan and other tributaries of the lower Kootenay are large streams with considerable fall.

The Pend d'Oreille river falls into the Columbia near the International boundary. With the exception of about twelve miles near its mouth and the upper portion of the Flathead tributary, it lies wholly within the United States. It has a total drainage area of about 30,000 square miles. It has been gauged by the United States Reclamation Service just below the mouth of Priest river; the minimum flow recorded was 5,419 cubic feet per second, on February 3rd, 1905, the next lowest, 7,852 cubic feet per second, was taken on January 19th, of the same year. There are two power sites on this stream, near Waneta, B.C., which can be developed under heads of 75 and 50 feet, giving an estimated capacity of 65,000 and 45,000 H.P., respectively.

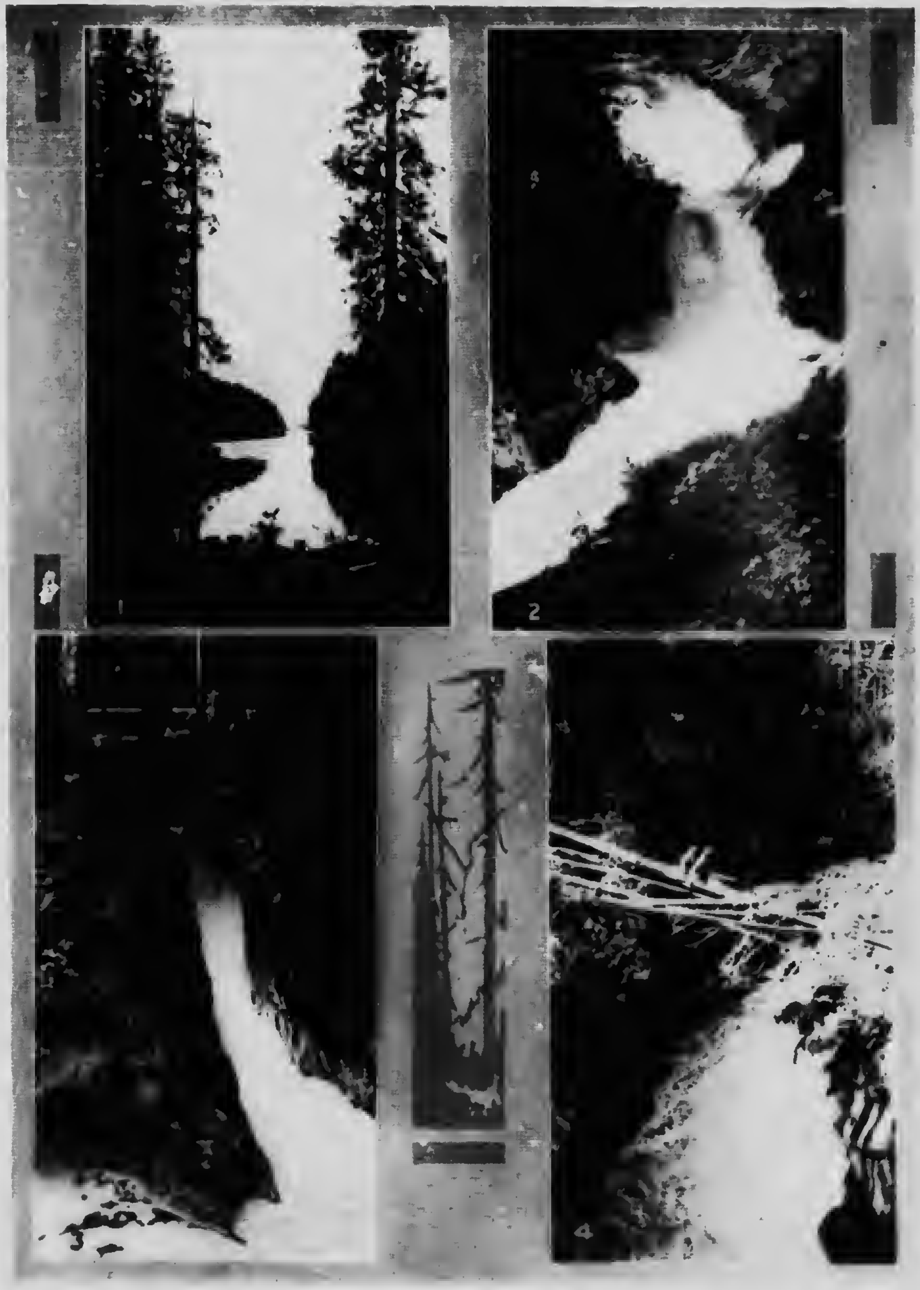
The Kettle, the Similkameen and their tributaries are also, affluents of the Columbia. While they contain numerous water power sites, the summer flow is considerably less than that of the glacier-fed streams.

Between the Skeena and the Fraser, no stream cuts across the Coast range. Consequently, in this area, all the rivers are short and steep, but on account of the very heavy precipitation on the west slope of the Coast range, they carry a heavy flow of water.

The Squamish empties into Howe Sound. It is 34 miles long and between Green lake and its mouth, a distance of 33 miles, falls 2,070 feet. Eight hundred feet of this fall occurs between Daisy lake and the mouth of the Minatch, a distance of nine miles, and 450 feet between the former and the "forks" of the Tcharkamisht.

The Homathko river rises in the Coast range at an altitude of 3,530 feet and is 92 miles long. Between Waddington canyon, 29th mile from tide-water, and Murderers bar, 32nd mile, it falls 350 feet; between the junction with the west branch, 37th mile, and head of Great canyon, 40th mile, it falls 470 feet.

The Bellacoola river also rises in the Coast range and is about 60 miles long. Between the mouth of Driver river and Bentinck North arm, it falls 1,100 feet.



1. Campbell Lake.
2. Big Slide Creek, Tributary to Skeena River
3. [illegible] Creek, Tributary Toba River. On one of the streams Canyons similar to this follow in succession for several miles
4. [illegible] River, Tributary to Homathko River. Most of the streams and tributaries pass through canyons

Dean river (also called Salmon river) rises in the Coast range near the headwaters of the Blackwater and Nechaco. Between the confluence with the Iltasyouco and the mouth, it falls 2,321 feet in 46¼ miles; between "Salmon House," at the 24th mile, and the "3rd crossing," quarter of a mile below, it descends 181 feet.

The Kemano river empties into Gardner inlet. Between Siffleur lake and tidewater, 18 miles, it falls 3,753 feet. Between the 9th and 12th miles from the mouth it descends 1,035 feet; of this descent, 214 feet occur in 1,000 feet horizontal.

Other rivers, south of the Skeena, that are known to contain valuable powers but for which no details are available, are: the Southgate, falling into Bute inlet; the Klinaklini, into Bute inlet; the Owikano, into Rivers inlet; the Kitlope, into Gardner canal; and the Kitimat into Douglas channel.

The Skeena river drains an area of 19,300 square miles and is 335 miles long. Between Hazelton and its mouth it has a fall of 725 feet but the construction of the Grand Trunk Pacific Railway will probably prevent damming it to raise the water to any considerable height. The Babine river, a tributary, drains Babine lake, which has an area of 306 square miles. Between the lake and Kitkargas village, a distance of about 40 miles, it falls 1,000 feet.

Other important streams are: the Nass draining 7,400 square miles and 205 miles long; the Stikine, with a drainage basin 20,300 square miles in area, and 355 miles long, and the Taku, draining 7,600 square miles.

The Peace River drains the north-eastern portion of British Columbia. Between the junction of the Finlay and Parsnip—where it takes the name "Peace"—and the eastern boundary of the Province, there are no water powers. Its south branch, the Parsnip is 145 miles long. Below the confluence of McLeod river, there are no rapids in the Parsnip. Above the McLeod, it is unsurveyed except the rough survey made by Mackenzie, in 1793. Some of its eastern tributaries, such as the Misinchinca, are torrential streams carrying a good flow of water. The Nation river, another tributary, is unexplored.

The north branch of the Peace—the Finlay—is 250 miles long. It ranges in width from 90 feet where is issues from the Fishing lakes, to 900 feet near its mouth. Its navigation, for 200 miles above its mouth, with the exception of Deserter canyon, is easy. Deserter canyon is situated about 90 miles above the mouth; is about half a mile long and, in the narrowest place, scarcely exceeds a hundred feet in width. The walls at the lower end are high. Where the Finlay flows through the Long canyon, above its confluence with the Tochieca, it is a succession of canyons, riffles and rapids, for many miles. The Long canyon is five miles long. The river, in places, is narrowed to less than 100 feet in width and contains numerous wild rapids. The total depth of the gorge, at the upper end exceeds 600 feet.

The Omincca, or south branch of the Finlay, is by far the largest tributary of the latter. The Black canyon, five miles from its mouth, is about half a mile in length and varies in width from one hundred to two hundred feet. Its walls are usually vertical and, in places, exceed 150 feet in height. Six miles above the mouth of the Oslinca, the Omineca flows through the Little canyon. Between the mouth and quiet water nine miles above Little canyon, the river falls 425 feet in a distance of 35 miles, an exceptionally high grade for a river of this size.

1. Tetachuck Lake, Rapids below Lake. Below the outlets of numerous lakes, rapids or falls occur.
2. Quesnel Lake, Dam at outlet. One of the larger possibilities including storage, but as will be seen from photograph there is nothing to indicate the magnitude of possible development. This photograph is included for the purpose of showing that photographs of this character would not be very impressive for publication. Dam here shown was built for gold mining purposes.
3. Glacier, Jones Lake Watershead.
4. Elk Falls, Campbell River.

VANCOUVER ISLAND

Vancouver Island is rich in water-powers, and from approximate estimates the total possibilities of them all cannot be less than 500,000 H.P. In addition to those powers already described, at Gold Stream, Puntledge and Jordan River, there are several great powers awaiting development, the largest of which is that at Campbell River on the north-east coast of the Island. This water power providing storage obtained in Buttles Lake, and the Upper and Lower Campbell Lakes, is capable of a development of 150,000 H.P. at an economical figure. Among other large powers are those at Great Central Lake, Sproat Lake and Stamp Falls near Alberni, Qualicum Falls, Cowichan Lake, Shawnigan Lake, and Nanaimo River. The Island has in addition to those mentioned, innumerable small powers that may be made commercially successful if used for the exploitation of the mineral resources of the Island.

HOW TO ACQUIRE A LICENCE TO TAKE AND USE WATER FOR POWER PURPOSES

THE administration of all water powers in British Columbia is now vested in the Province, including those within the Railway Belt formerly administered by the Dominion Government.

The Province has been divided into thirty-one "Water Recording Districts," the boundaries of which follow as nearly as possible the main watersheds, and a "Local Recorder," in most cases the Government Agent, appointed for each District. The local recorder acts as a "Recorder," the active administration in the more important districts being in the hands of a "District Engineer" whose duties are defined by the "Water Act, 1914," and who is subject to the Comptroller of Water Rights, whose office is at Victoria, B.C., and in whom alone is vested the power to approve an application and grant a licence. The printed forms of notice, application, etc., may be obtained on application to the office of any Water Recorder, District Engineer, or to the Comptroller's office.

Licences may be granted for the use of water for any of the following purposes:—Domestic, Water-works, Mineral-trading, Irrigation, Mining, Steam, Fluming, Hydraulicing, Miscellaneous, Power, Clearing-streams, Storage, Conveying and Lowering Water, but as this chapter deals only with the acquisition of a licence for the use of water for the development of power, the procedure in that connection only will be given.

As the water may be required in varying quantities, the applications have been classified as follows:—"Class A," "Class B" and "Class C," the definitions of these classes, as far as they relate to the development of power being as follows:—

"Class A"—Where the power to be developed does not exceed 100 H.P. and is to be used by the applicant only.

"Class B"—Where the power to be developed exceeds 100 H.P. and is to be used by the applicant only.

1. Undeveloped Water Power. Campbell Lake looking towards Slough leading to McIvor Lake.
2. Mussel Inlet. Fall typical of many on the coast as the streams leap into salt water. 400 feet fall in ½ mile.
3. Quesnel River, North Fork. Showing typical rapids and boulder stream bed.
4. Hydraulic Mining, Quesnel River District. Many of the high heads available afford power for hydraulic sluicing.

"Class C"—Where the power to be developed is to be sold, bartered or exchanged.

A licence in respect of a "Class A" or "Class B" application can be obtained by an "owner." "Owner" being defined by the Act as:—

(a) Any registered owner in the book of indefeasible or absolute fees in any Land Registry Office in the Province;
(b) Any purchaser or lessee in a registered agreement for purchase or lease;
(c) Any applicant to register his title as owner or his agreement for purchase or lease;
(d) Any pre-emptor, homsteader, or purchaser from the Crown in the right of either the Dominion or the Province, or any applicant to so pre-empt, homestead or purchase;
(e) Any timber licencee or lessee;
(f) Any other lawful occupant of land or of a mine;
(g) Any legal representative of an owner (as herein defined) who has died, become insolvent, is a minor, is of unsound mind, or is otherwise under disability;
(h) Any liquidator of a Company which is the owner of the land (as herein defined).

A licence in respect of a "Class C" application can only be acquired by a municipality empowered by an Act of the Legislature to acquire a licence for power purposes, or to a company authorized by its memorandum of association or by some Act of the Legislature to acquire a licence for that purpose, and in no case until the undertaking has been approved under the "Water Act, 1914."

The following is the procedure relating to the posting and filing of the notice and application for the licence:—

(1) The applicant shall post on the ground at conspicuous points near the proposed point of diversion and proposed place of use a notice of his intention to apply for a licence; although printed forms are supplied, the Act does not require that the notice follow any particular form, but it must give the following particulars:—

(a) The name and address of the applicant;
(b) The Water Recorder's office in which the application is to be filed;
(c) The name or a clear description of the stream the water of which is to be diverted or used;
(d) The quantity of water applied for in acre-feet per annum, cubic feet per second, gallons per day, or miners inches;
(e) The proposed point or points of diversion;
(f) The purpose for which the water is to be used;
(g) The number of the lot or section (and, if subdivided, the number or description of the subdivision) of the land or mine, and, if a mine, the name of the mine, upon which land or mine the water or power is to be used; and, in the case of a "Class C" application, a description of the territory within which the powers of the municipality or company in respect of its undertaking are to be exercised;
(h) The date when the notice was posted on the ground.

1. Little Qualicum Falls, Vancouver Island.
2. Stamp River Falls, Vancouver Island.
3. Granite Creek, tributary to Skeena River. Typical of many smaller Falls in British Columbia

Forthwith after the posting of the notice on the ground as above, notices to the same effect shall be filed in the office of the Water Recorder for the District in which the proposed point of diversion is situate, and served upon each owner whose land will be touched or in any way affected by the proposed works.

A notice giving all the particulars mentioned above, and, in addition, the date of the first publication and stating that objections may be filed with the Comptroller or with the Water Recorder within thirty days from such date, shall forthwith be published once a week for four weeks in a newspaper published in each district affected; and, in the case of a "Class C" application, stating that the petition for the approval of the undertaking will be heard in the office of the Board of Investigation at a date to be fixed by the Comptroller; and that objections may be filed to the petition as above. In addition to the advertising mentioned above, a "Class C" applicant must publish his notice for two weeks in the B. C. Gazette.

Within ten days from the first appearance of the notice in the local paper the application on forms to be supplied, must be filed in duplicate together with a sketch, also in duplicate, in the office of the Water Recorder where the notice was filed. The sketch need not be to scale but must show the point of diversion, the lands crossed or affected, and, generally outlining the scheme. The local recorder then forwards the application to the Comptroller who checks the application and advises the applicant of the further requirements and of the amount of the fees payable. This further information and the fees, as well as the petition for the approval of the undertaking, must be filed with the Comptroller within fifty days from the first appearance of the notice in the local paper. The petition for approval of the undertaking is to be addressed to the Minister of Lands and filed with the Comptroller and shall set forth the following particulars:—

(a) That a copy of the application and plan is attached, and giving the main features pertaining thereto;

(b) The water district in which the works are situate, the place where the water is to be used, and the territory over which the business of the company will extend;

(c) Such particulars with regard to capital as will satisfy the requirements of subsection (5) of section 11;

(d) The time proposed for the commencement and completion of works;

(e) That the fees prescribed by the "rules" for filing petition and for certificate of approval have been paid to the Comptroller;

(f) The names of the parties upon whom the Act requires notice to be served shall be entered at the foot of the petition;

(g) The name of the newspaper and the date of the first and subsequent publications in said newspaper and in the Gazette shall be entered at the foot of the petition.

This petition, together with any objections, is then reported on by the Board of Investigation, and if the Minister considers the undertaking to be in the public interest he grants a certificate of approval. The certificate will set out the terms and conditions as to capital to be paid up, the amount of the bond, which shall be not less than five times the record fee, to be filed by the company, guaranteeing the performance in good faith of the undertaking, and the territory within which the company may operate and such other terms as he may consider in the public interest. When the certificate has been issued it is to be filed with the Comptroller and advertised at the expense of the applicant.

The Comptroller is now in a position to consider the application for the licence and if it is found to be in order will issue an authorization to the applicant to proceed to survey and file plans of his proposed works setting the time within which they must be completed and the manner in which they are to be made. The plans are to be submitted in triplicate, one set of tracings and two sets of prints and must be in such detail that the construction of the works could be carried out from them.

The fees to be paid in respect of a licence are as follows:—

RECORD FEE:—	Each available H.P. up to 1000	$ .50
	Each additional H.P. up to 5000	.25
	Each additional H.P. above 5000	.10

ANNUAL RENTAL:—During the survey construction period, or until such time as the power is developed and sold an amount is payable each year equal to the record fee.

After the plant is in operation a rental is fixed by the Board of Investigation who take into consideration all such items as cost of development, demand for power, etc., etc., and fix the rental. The rental shall be not less than 25 cents per H.P. and not more than $1.00 per H.P. per annum, and shall be readjusted every five years.

If, in the opinion of the Comptroller, the work has been carried on with due diligence the fees paid in during the survey-construction period may be credited to the cancellation of charges as they become due during the operation period.

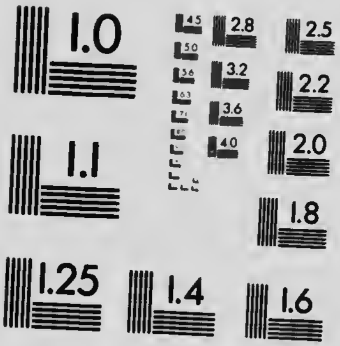
After the plans have been filed and approved by the Comptroller he will issue a conditional licence which constitutes the approval of the plans, fixes the amount of water to be used, and sets a time for the commencement and completion of the works, and authorizes the use of the water.

Within sixty days of the date set for the completion of the works the licensee will file proof of such completion and the Comptroller when he has satisfied himself by inspection or otherwise that the work has been carried out in a satisfactory manner, will issue a final licence.

While the above is an outline of the procedure to obtain a licence for the use of water in the development of power, for full particulars of the rights and obligations of licensees interested parties are referred to the "Water Act, 1914," and the rules and regulations thereunder, copies of which, as well as detailed information and forms, may be obtained from Mr. William Young, the Comptroller of Water Rights, Victoria, B.C.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



APPLIED IMAGE Inc
1653 East Main Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phone
(716) 288 - 5989 - Fax

For further information regarding water powers in Canada, application should be made direct to the following administrative officers of the Dominion and the various Provincial Governments:

◆

Province of British Columbia: The Comptroller of Water Rights, Victoria, B.C.

Provinces of Manitoba, Saskatchewan and Alberta: The Superintendent of the Dominion Water Power Branch, Ottawa, Ont.

Province of Ontario: The Deputy Minister of Lands, Forests and Mines, Toronto, Ont; also, to the Secretary of the Hydro-Electric Power Commission of Ontario, Toronto, Ont.

Province of Quebec: The Chief Engineer, Hydraulic Service, Department of Lands and Forests, Quebec, Que.

Province of New Brunswick: Surveyor-General of New Brunswick, Fredericton, N.B.

Province of Nova Scotia: The Secretary of the Nova Scotia Water Power Commission, Halifax N.S.